Supplement to Final Design Report - Overview of Numerical Modeling Supporting the Design of the Active Layer in the River Mile 10.9 Engineered Sediment Cap

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This memorandum provides an overview of the numeric modeling that was performed to design the active layer of the engineered sediment cap to be constructed as part of the Removal Action at River Mile (RM) 10.9. Four COPC groups were included in the modeling activities: dioxins/furans, total PCBs, PAHs, and mercury. The organic COPC groups were characterized by a representative chemical constituent (shown in the parentheses): dioxins/furans (2,3,7,8-TCDD), total PCBs (PCB-52), and PAHs (phenanthrene). The representative chemical constituent for COPC groups were selected for their relative mobility and/or toxicity. Phenanthrene and PCB-52, for example, have lower molecular weight and moderate sorption capacity in sediment, which make them more mobile compared to the heavier and stronger sorbing counterparts. Selecting the more mobile constituents results in a more protective/conservative indicator of potential future breakthrough for the given COPC group. The dioxin/furan congener 2,3,7,8-TCDD was selected for the cap modeling due to its lower molecular weight and because it is the most toxic and most prevalent dioxin/furan congener present in RM 10.9 Removal Area sediment.

Sediment Cap Numerical Model: CapSim

The numerical model CapSim (version 2.6; Reible 2012) was used to predict the potential transport of COPCs through the active layer of the engineered sediment cap using site-specific values for key model input parameters. The model considers chemical transport via advection, molecular diffusion, adsorption, dispersion, and chemical decay. The CapSim model estimates pore water concentrations through and above the various cap layers, which are influenced by contaminant migration from the sediment below the cap (i.e., the sediment remaining after dredging). Because the RM 10.9 Removal Area COPCs are highly adsorptive to carbon, their migration through a sediment cap can be significantly retarded by an active layer (chemical isolation layer) comprising activated carbon. The CapSim model provides a means to evaluate the required thickness of the active layer to achieve the design criteria.

Throughout the evaluation process Dr. Danny Reible, the CapSim model developer, was consulted to verify that the selected input parameters were representative of conditions at the RM 10.9 Removal Area and to ensure that the model output was suitable for design of the active layer of the cap.

Design Criteria and Input Parameters

The active layer of the engineered sediment cap was designed to prevent breakthrough of the key COPCs over a 100-year period. Breakthrough is defined as pore water concentrations exceeding the New Jersey Surface Water Quality Standards (NJSWQS), NJAC 7:9B Fresh Water (FW2) Criteria for Human Health. In the model simulations,

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the depth at which pore water concentrations were compared against the breakthrough criteria is the interface between the active layer and the armor layer, as shown in Figure 1. Since concentrations will continue to decrease as pore water travels through the 12 inch armor layer to the surface of the sediment cap, using this depth to evaluate potential exceedances of breakthrough criteria provides an element of conservatism into the design to ensure the final cap design is protective of human health and the environment.

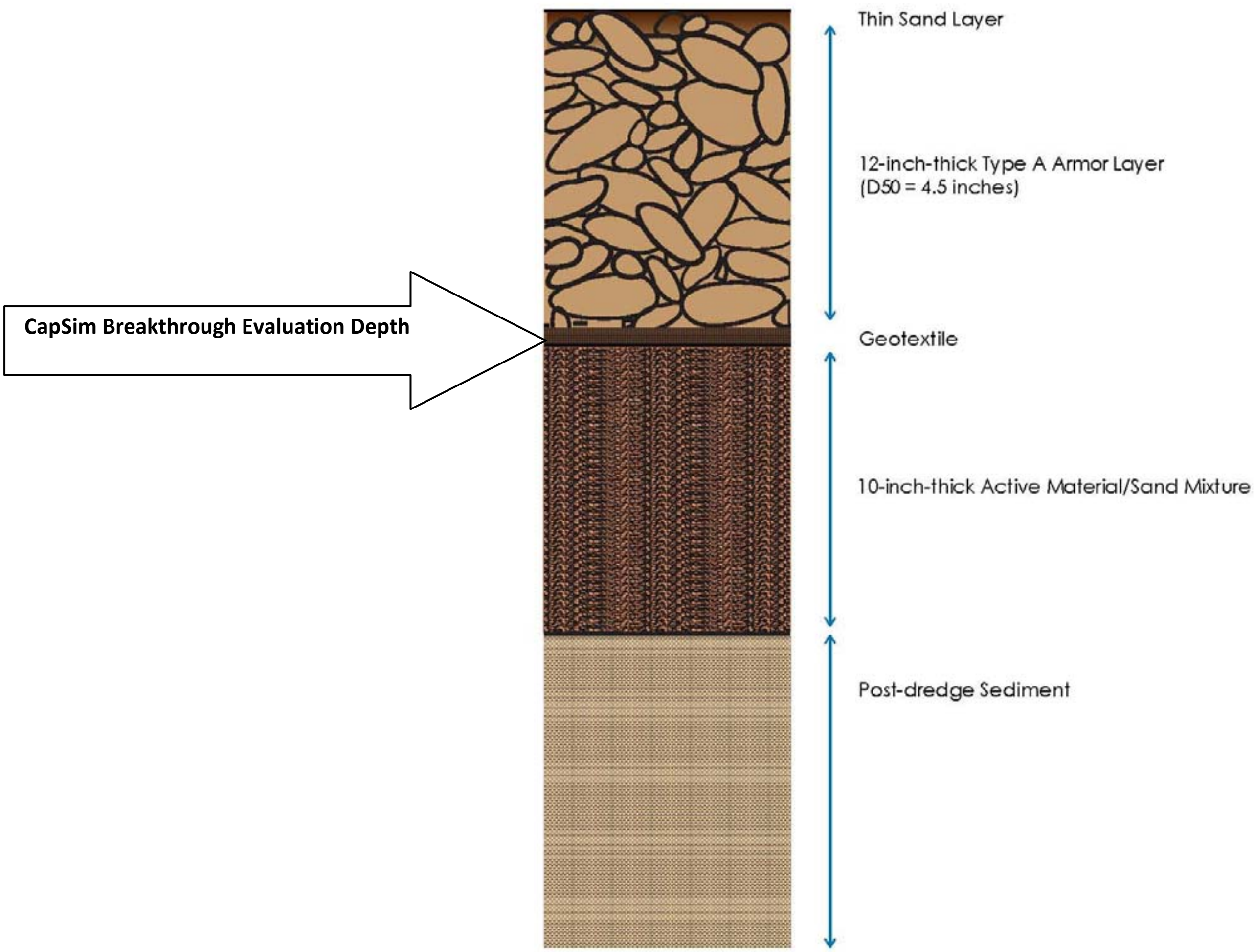


FIGURE 1. CapSim Model Depth of Interest for Evaluation of Breakthrough Criteria

Site-Specific Groundwater Seepage Velocity and Pore Water Chemistry

The design of the cap's active layer utilized two sets of site-specific data as inputs to the CapSim model – groundwater seepage velocity and pore water chemistry . The groundwater seepage velocity input parameter was based on the average of each of the four monitoring stations where groundwater seepage was measured in April 2013 (see Table 1 and Attachment 2). The pore water chemistry data were obtained in February 2013 (see Table 2) by averaging the results of pore water composite samples generated from sediment cores collected from locations with the 10 highest sediment concentrations of PCDDs/PCDFs, PCBs, and mercury[1] within the 2 to 4 ft depth interval (below the sediment cap). Thus, the pore water chemistry data are biased high and since the pore

[1] Sediment data collected during the 2011 and 2012 characterizations of the RM 10.9 were used to identify pore water sampling locations.

water concentrations are proportional to sediment concentrations, many areas within the Removal Area will have concentrations in pore water that are orders of magnitude lower than those used in the CapSim modeling.

TABLE 1. SITE-SPECIFIC GROUNDWATER SEEPAGE VELOCITY

Results (cm/day)	Station 1	Station 2	Station 3	Station 4
Minimum	-1.61	-0.28	-0.02	-0.45
Maximum	2.50	6.46	0.12	0.78
Standard Deviation	1.50	2.27	0.04	0.41
Average	0.53	2.56	0.07	0.20
Station Average (cm/year)	193	934	26	73
Area Average (cm/year)	**307**			

TABLE 2. SITE-SPECIFIC COMPOSITE PORE WATER CONCENTRATIONS (ug/L)

Sample	2,3,7,8-TCDD	Total PCBs	Mercury	Phenanthrene
Pore Water Composite 1	0.0052	15.9	0.0018	1.70
Duplicate 1	0.0049	16.3	0.0028	1.69
Pore Water Composite 2	0.0044	14.3	0.0012	0.69
Duplicate 2	0.0042	13.4	--	0.76
Pore Water Composite 3	0.0044	12.0	--	1.66
Duplicate 3	0.0044	11.2	--	--
Average	**0.0046**	**13.9**	**0.0020**	**1.30**

Note: Compete analytical dataset is provided in Attachment 3

Additional CapSim Input Parameters

Two other model input parameters – biochemical degradation and deposition of clean sediment – were set to zero to provide a more conservative design. The chemical isolation provided by an active cap allows time for slow degradation processes (e.g., anaerobic biodegradation/reductive dechlorination) to occur, which act to decrease the overall chemical flux into the biologically active zone and the overlying surface water. The CapSim modeling results have additional conservatism built in to them by setting the biochemical decay input parameter to zero. Net deposition was also set to zero in the CapSim modeling to be conservative, because natural recovery can occur from the deposition of clean sediment at the cap-water interface.

Since the pore water samples were generated via centrifugation of sediments followed by settlement of solids, and the organic COCPs were not filtered, the measured concentrations were orders of magnitude higher than the corresponding freely dissolved concentrations called for in the CapSim model. These site-specific pore water concentration values inherently include additional contributions from chemicals associated with dissolved organic matter (DOM) and other fractions. The use of these centrifuged pore water values to represent freely dissolved concentrations adds another degree of conservatism to the cap design. After review of the pore water concentration data, Dr. Danny Reible recommended that CH2M Hill set the CapSim input parameter for dissolved organic matter to zero because the site-specific measured pore water values include the COPC concentrations associated with the DOM fraction.

CapSim Results

The CapSim model application for RM 10.9 takes a conservative approach to modeling the design and effectiveness of the active layer of the engineered sediment cap:

- Comparison of pore water concentrations to design criteria at the active layer/armor layer interface
- Intentional high bias of the pore water data set
- Use of pore water values generated via centrifugation that include the freely dissolved fraction
- Setting natural attenuation input factors (biochemical degradation and sediment deposition) to zero

The CapSim model simulations indicate that 2.5 inches of AquaGate+PAC™ composite particles containing 10 percent activated carbon manufactured by AquaBlok® will be effective in preventing breakthrough in excess of the cap's design criteria of 100 years at the average seepage velocity for the RM10.9 Removal Area. However, the effective sorptive capacity of the cap increases by distrbuting the active material over the entire thickness of the sand/active layer. Distribution throughout the sand/active layer decreases concentration gradients (diffusive transport) and increases the residence time through the sand/active layer where sorption is occurring. An increase in sand/active layerperformance on the order of more than 2-3X can be achieved by distributing the active material over a 10 inch thickness. For this reason, the final design incorporates 10 inches of mixed active material/sand, which protects against breakthrough in excess of 250 years as shown in Attachment 1. Even at the highest station average groundwater flux, the cap will be protective for more than 100 years.

ATTACHMENT 1

CapSim Model Input / Output Summary Sheets

Cap Model Summary and Results: Total PCBs (PCB-52)

Selected System Properties	Values	References
Pore water concentration, µg/L	13.85	Site specific average (total PCBs)
Darcy velocity, cm/yr	307	Site specific average
Dissolved Organic Matter, mg/L	0	Since pore water was extracted conventionally via centrifugation, measured concentrations inherently include chemical concentrations associated with DOM. For centrifuged samples this parameter is to be set to zero per Dr. Danny Reible.
Bioturbation Layer, cm	15	Typical bioturbation layer thickness
Deposition velocity, cm/yr	0	Conservative assumption as deposited sediment layer adds thickness to the cap that can contribute to contaminant attenuation over time.
Total consolidation, cm	23	Conservative estimate based on engineering judgment
Time to 90% consolidation, yr	1	Conservative estimate based on engineering judgment

Active Layer Details: Mixture of 25% (v/v) AquaGate+PAC™ (with 10% AC) and 75% (v/v) sand

Cap Layers Properties	Active Layer (Activated Carbon/ Sand Mixture)	Underlying Native Sediment
Thickness (cm)	25.4 (10 inches)	NA
Active Material	Activated Carbon (AquaGate+PAC™)	Native Sediment
Bulk density (g/cm3)	0.026 (bulk density of activated carbon fraction in mixture)	1.6
Porosity (weighted average of mixture)[1]	0.363	0.65
Sorption Isotherm	Freundlich	Linear-$K_{oc}f_{oc}$
Activated Carbon Freundlich K_f coefficient[2]	1.78E+06	NA
Activated Carbon Freundlich N coefficient[2]	0.86	NA
Organic carbon fraction[3] (foc)	NA	0.056
Hydrodynamic dispersivity[4] (average), cm	2.76	2.76

Notes:

NA = Not applicable

[1] US Department of Energy (2009). PNNL-18801, September, p. 2.1.

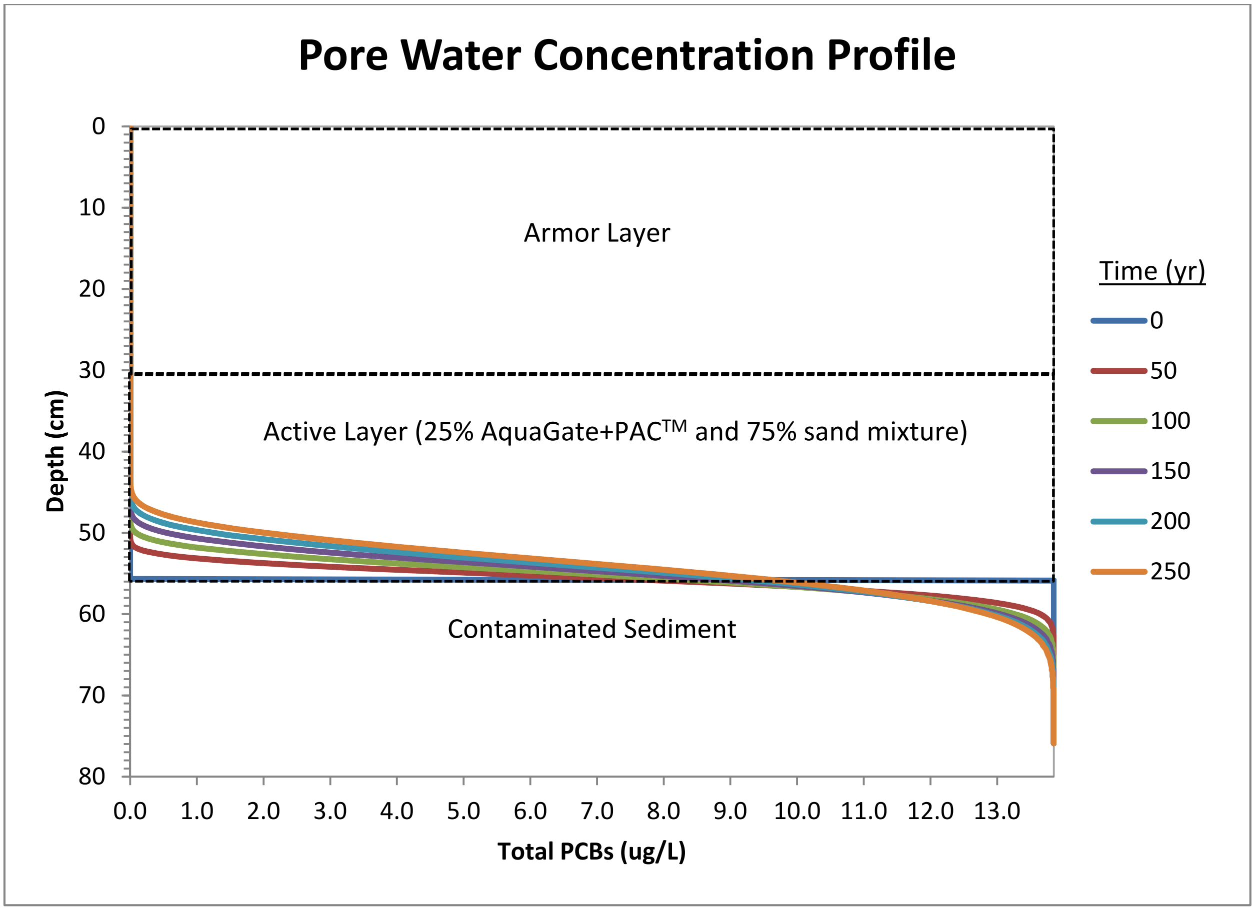
[2] McDonough et al., 2008. Water Research, 42, p 575-584.

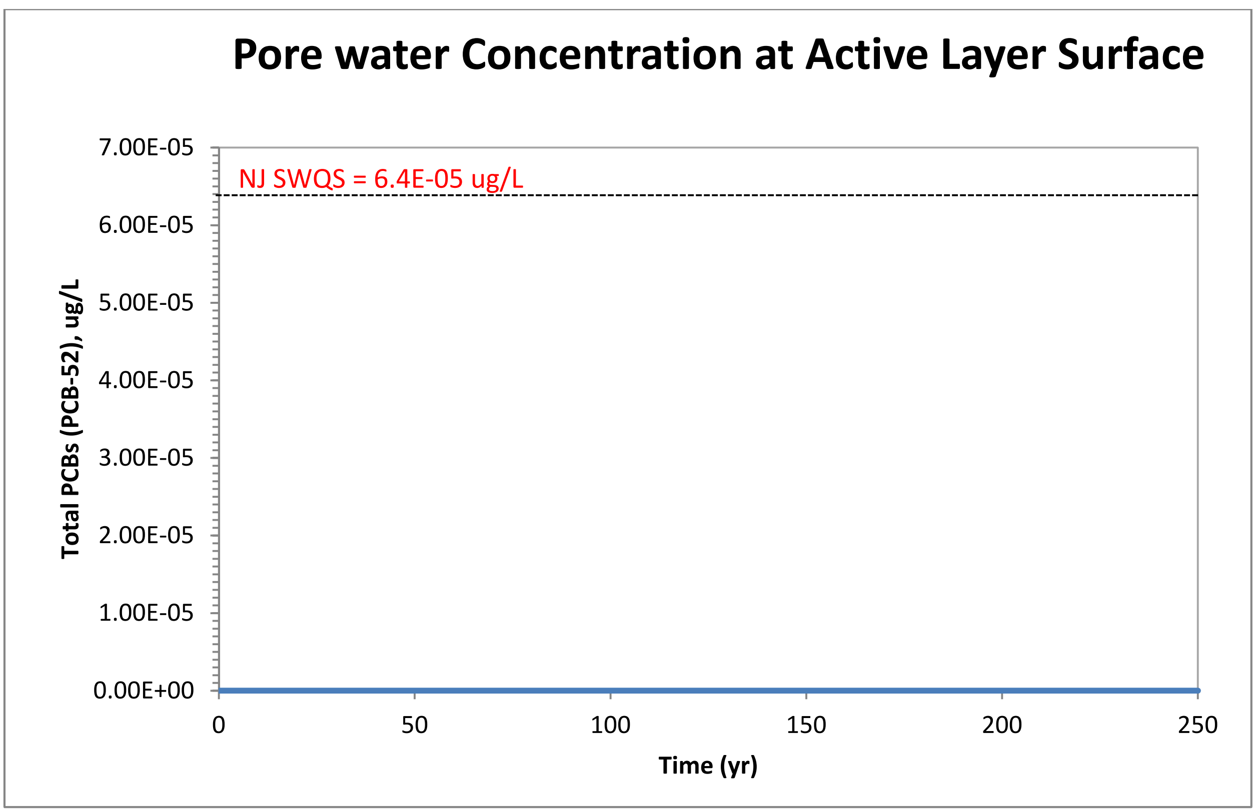
[3] Site specific average value for the 2.5'-3.5' bgs sediment interval.

[4] Calculated value provided by Dr. Danny Reible based upon site specific upwelling velocity and tidal fluctuations.

Breakthrough Criteria: New Jersey Surface Water Quality Standards (NJSWQS). NJAC 7:9B Fresh Water (FW2) Criteria for Human Health.

NJ SWQS criterion for total PCBs = 6.4 x 10-5 µg/L


Pore Water Concentration Profile
Armor Layer
Active Layer (25% AquaGate+PAC™ and 75% sand mixture)
Contaminated Sediment
Depth (cm)
0
10
20
30
40
50
60
70
80
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
Total PCBs (ug/L)
Time (yr)
0
50
100
150
200
250


Pore water Concentration at Active Layer Surface
NJ SWQS = 6.4E-05 ug/L
Total PCBs (PCB-52), ug/L
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
0
50
100
150
200
250
Time (yr)

Cap Model Summary and Results: 2,3,7,8-TCDD

Selected System Properties	Values	References
Pore water concentration, µg/L	0.00458	Site specific average
Darcy velocity, cm/yr	307	Site specific average
Dissolved Organic Matter, mg/L	0	Since pore water was extracted conventionally via centrifugation, measured concentrations inherently include chemical concentrations associated with DOM. For centrifuged samples this parameter is to be set to zero per Dr. Danny Reible.
Bioturbation Layer, cm	15	Typical bioturbation layer thickness
Deposition velocity, cm/yr	0	Conservative assumption as deposited sediment layer adds thickness to the cap that can contribute to contaminant attenuation over time.
Total consolidation, cm	23	Conservative estimate based on engineering judgment
Time to 90% consolidation, yr	1	Conservative estimate based on engineering judgment

Active Layer Details: Mixture of 25% (v/v) AquaGate+PAC™ (with 10% AC) and 75% (v/v) sand

Cap Layers Properties	Active Layer (Activated Carbon/ Sand Mixture)	Underlying Native Sediment
Thickness (cm)	25.4 (10 inches)	NA
Active Material	Activated Carbon (AquaGate+PAC™)	Native Sediment
Bulk density (g/cm3)	0.026 (bulk density of activated carbon fraction in mixture)	1.6
Porosity (weighted average of mixture)[1]	0.363	0.65
Sorption Isotherm	Freundlich	Linear-$K_{oc}f_{oc}$
Activated Carbon Freundlich K_f coefficient[2]	7.94E+06	NA
Activated Carbon Freundlich N coefficient[2]	0.68	NA
Organic carbon fraction[3] (foc)	NA	0.056
Hydrodynamic dispersivity[4] (average), cm	2.76	2.76

Notes:

NA = Not applicable

[1] US Department of Energy (2009). PNNL-18801, September, p. 2.1.

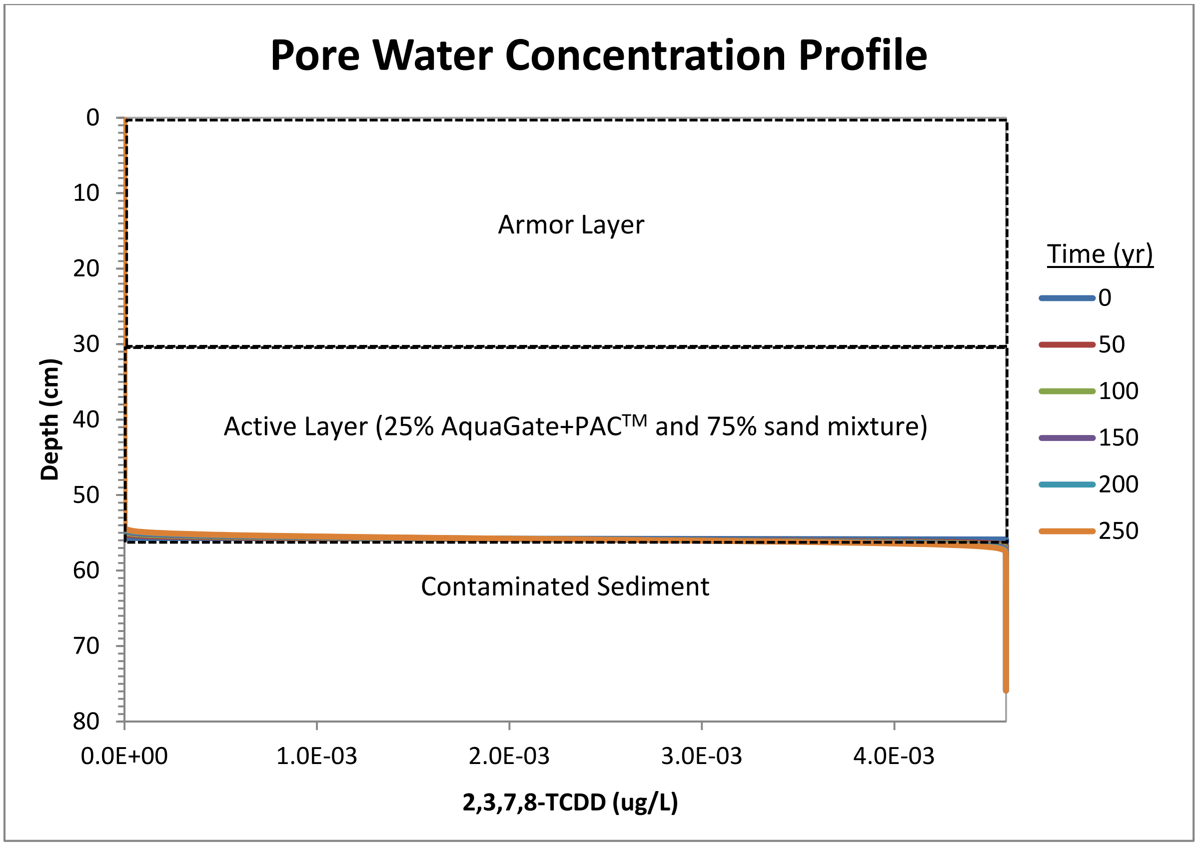
[2] Freundlich Coefficients for PCB-126 were used to conservatively estimate 2,3,7,8-TCDD adsorption onto activated carbon as recommended by Dr. Ghosh. The PCB-126 congener was selected for this purpose because its octanol water partition coefficient is similar to that of 2,3,7,8-TCDD. Source for Freundlich coefficients: McDonough et al., 2008. Water Research, 42, pp. 575-584.

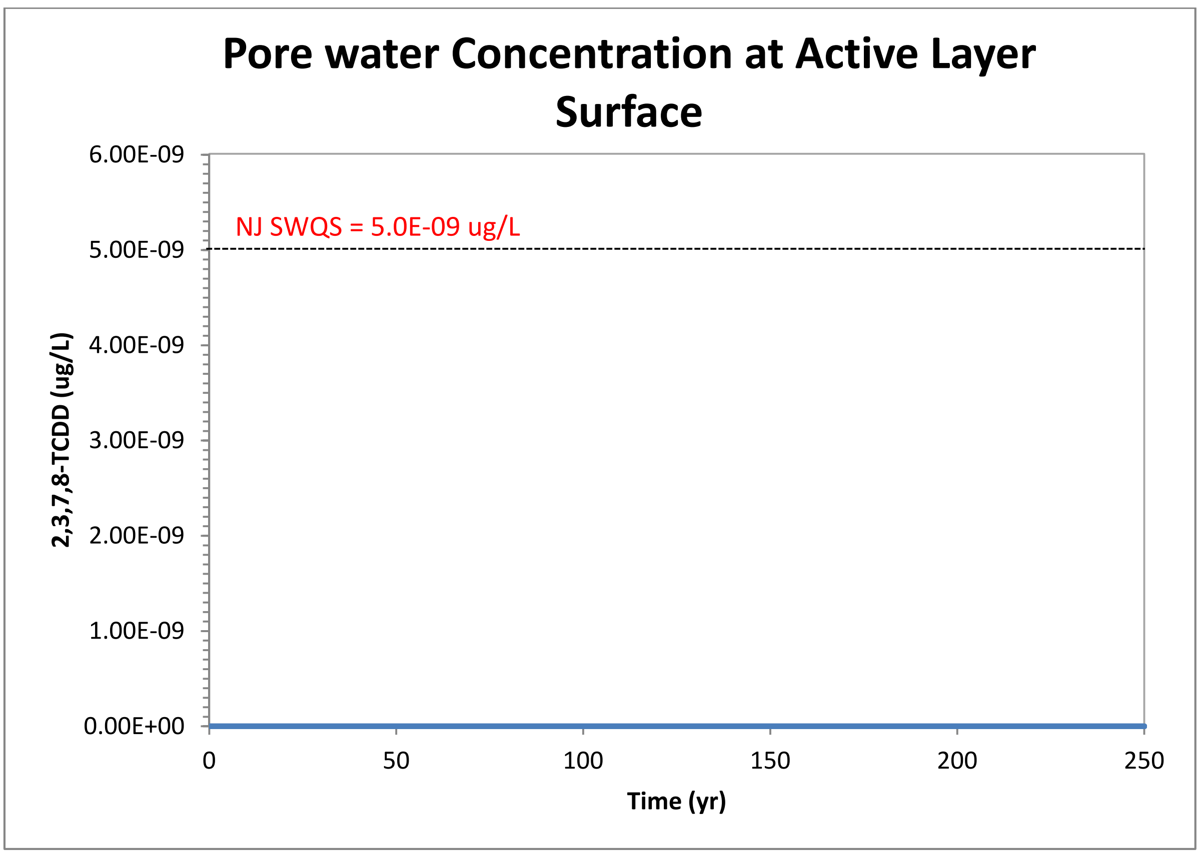
[3] Site specific average value for the 2.5'-3.5' bgs sediment interval.

[4] Calculated value provided by Dr. Danny Reible based upon site specific upwelling velocity and tidal fluctuations.

Breakthrough Criteria: New Jersey Surface Water Quality Standards (NJSWQS). NJAC 7:9B Fresh Water (FW2) Criteria for Human Health.

NJ SWQS criterion for 2,3,7,8-TCDD = 5 x 10-9 µg/L


Pore Water Concentration Profile
Armor Layer
Active Layer (25% AquaGate+PACTM and 75% sand mixture)
Contaminated Sediment
Depth (cm)
0
10
20
30
40
50
60
70
80
0.0E+00
1.0E-03
2.0E-03
3.0E-03
4.0E-03
2,3,7,8-TCDD (ug/L)
Time (yr)
0
50
100
150
200
250


Pore water Concentration at Active Layer Surface
NJ SWQS = 5.0E-09 ug/L
2,3,7,8-TCDD (ug/L)
6.00E-09
5.00E-09
4.00E-09
3.00E-09
2.00E-09
1.00E-09
0.00E+00
0
50
100
150
200
250
Time (yr)

Cap Model Summary and Results: Mercury

Selected System Properties	Values	References
Pore water concentration, µg/L	0.00196	Site specific average
Darcy velocity, cm/yr	307	Site specific average
Dissolved Organic Matter, mg/L	0	Since pore water was extracted conventionally via centrifugation, measured concentrations inherently include chemical concentrations associated with DOM. For centrifuged samples this parameter is to be set to zero per Dr. Danny Reible.
Bioturbation Layer, cm	15	Typical bioturbation layer thickness
Deposition velocity, cm/yr	0	Conservative assumption as deposited sediment layer adds thickness to the cap that can contribute to contaminant attenuation over time.
Total consolidation, cm	23	Conservative estimate based on engineering judgment
Time to 90% consolidation, yr	1	Conservative estimate based on engineering judgment

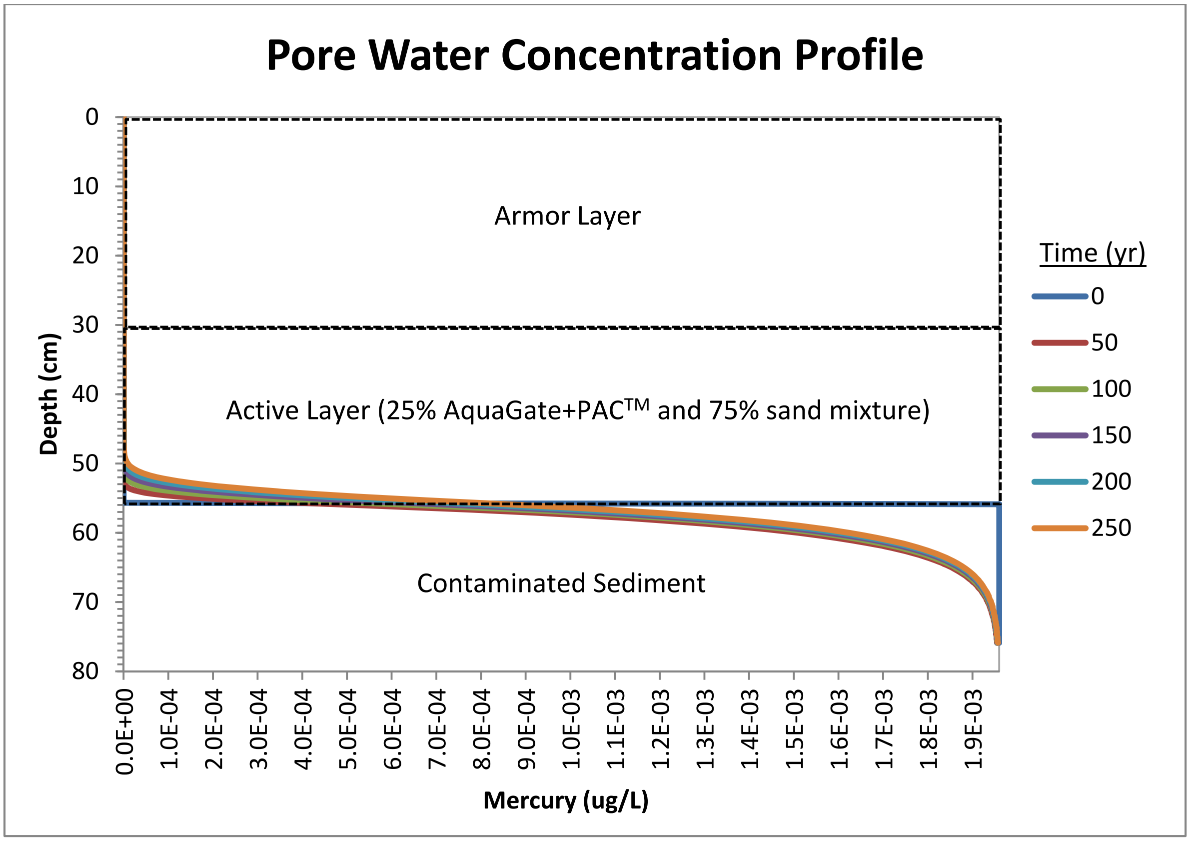
Active Layer Details: Mixture of 25% (v/v) AquaGate+PAC™ (with 10% AC) and 75% (v/v) sand

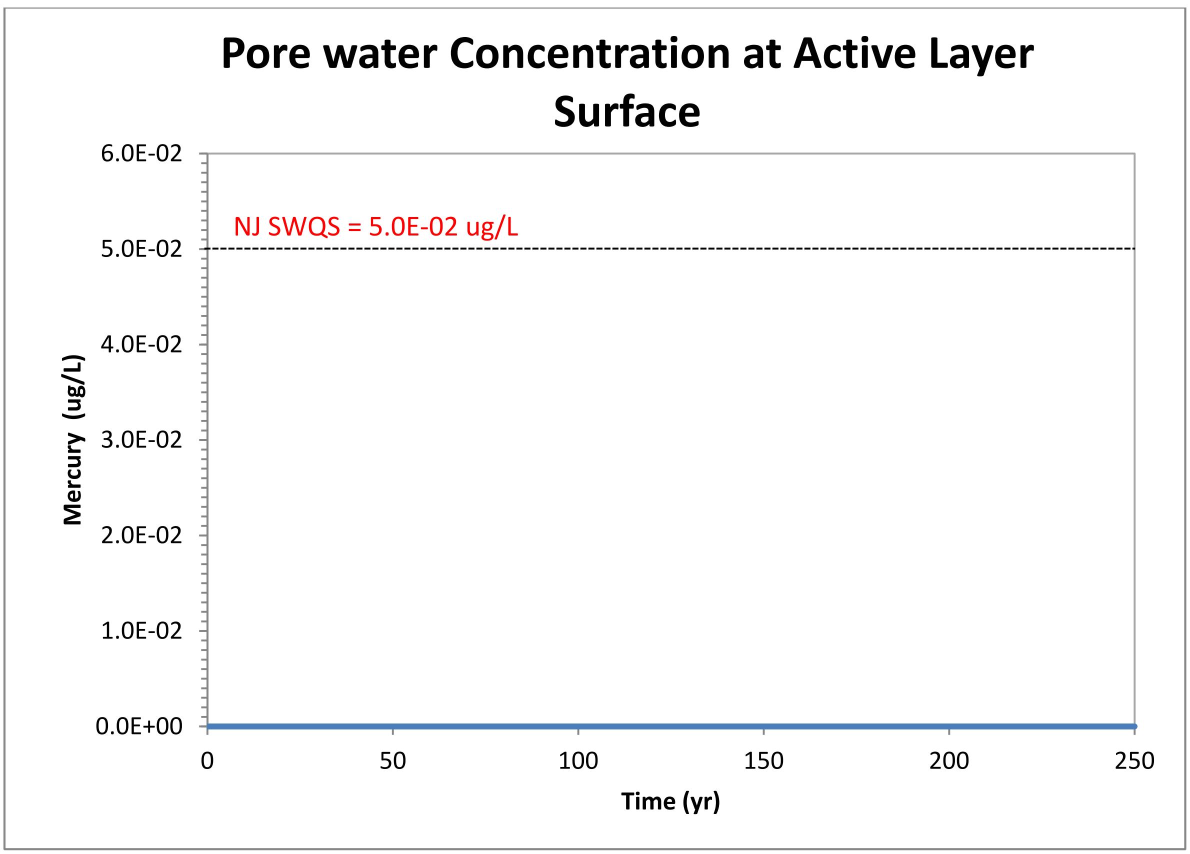
Cap Layers Properties	Active Layer (Activated Carbon/ Sand Mixture)	Underlying Native Sediment
Thickness (cm)	25.4 (10 inches)	NA
Active Material	Activated Carbon (AquaGate+PAC™)	Native Sediment
Bulk density (g/cm3)	0.026 (bulk density of activated carbon fraction in mixture)	1.6
Porosity (weighted average of mixture)[1]	0.363	0.65
Sorption Isotherm	Linear Kd specified	Linear-$K_{oc}f_{oc}$
Activated Carbon-water partition coefficient[2]	4.0E+06	NA
Organic carbon fraction[3]	NA	0.056
Hydrodynamic dispersivity[4] (average), cm	2.76	2.76

Notes:
NA = Not applicable
[1] US Department of Energy (2009). PNNL-18801, September, p. 2.1.
[2] Activated Carbon-water partition coefficient = K_{AC} range (4.0E+06 – 2.0E+07) provided by Dr. Upal Ghosh.
[3] Site specific average value for the 2.5'-3.5' bgs sediment interval.
[4] Calculated value provided by Dr. Danny Reible based upon site specific upwelling velocity and tidal fluctuations

Breakthrough Criteria: New Jersey Surface Water Quality Standards (NJSWQS). NJAC 7:9B Fresh Water (FW2) Criteria for Human Health.

NJ SWQS criterion for Mercury = 5×10^{-2} µg/L


Pore Water Concentration Profile
Armor Layer
Active Layer (25% AquaGate+PAC™ and 75% sand mixture)
Contaminated Sediment
Depth (cm)
0
10
20
30
40
50
60
70
80
Mercury (ug/L)
0.0E+00
1.0E-04
2.0E-04
3.0E-04
4.0E-04
5.0E-04
6.0E-04
7.0E-04
8.0E-04
9.0E-04
1.0E-03
1.1E-03
1.2E-03
1.3E-03
1.4E-03
1.5E-03
1.6E-03
1.7E-03
1.8E-03
1.9E-03
Time (yr)
0
50
100
150
200
250


Pore water Concentration at Active Layer Surface
NJ SWQS = 5.0E-02 ug/L
Mercury (ug/L)
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E+00
0
50
100
150
200
250
Time (yr)

Cap Model Summary and Results: Phenanthrene

Selected System Properties	Values	References
Pore water concentration, µg/L	1.298	Site specific average
Darcy velocity, cm/yr	307	Site specific average
Dissolved Organic Matter, mg/L	0	Since pore water was extracted conventionally via centrifugation, measured concentrations inherently include chemical concentrations associated with DOM. For centrifuged samples this parameter is to be set to zero per Dr. Danny Reible.
Bioturbation Layer, cm	15	Typical bioturbation layer thickness
Deposition velocity, cm/yr	0	Conservative assumption as deposited sediment layer adds thickness to the cap that can contribute to contaminant attenuation over time.
Total consolidation, cm	23	Conservative estimate based on engineering judgment
Time to 90% consolidation, yr	1	Conservative estimate based on engineering judgment

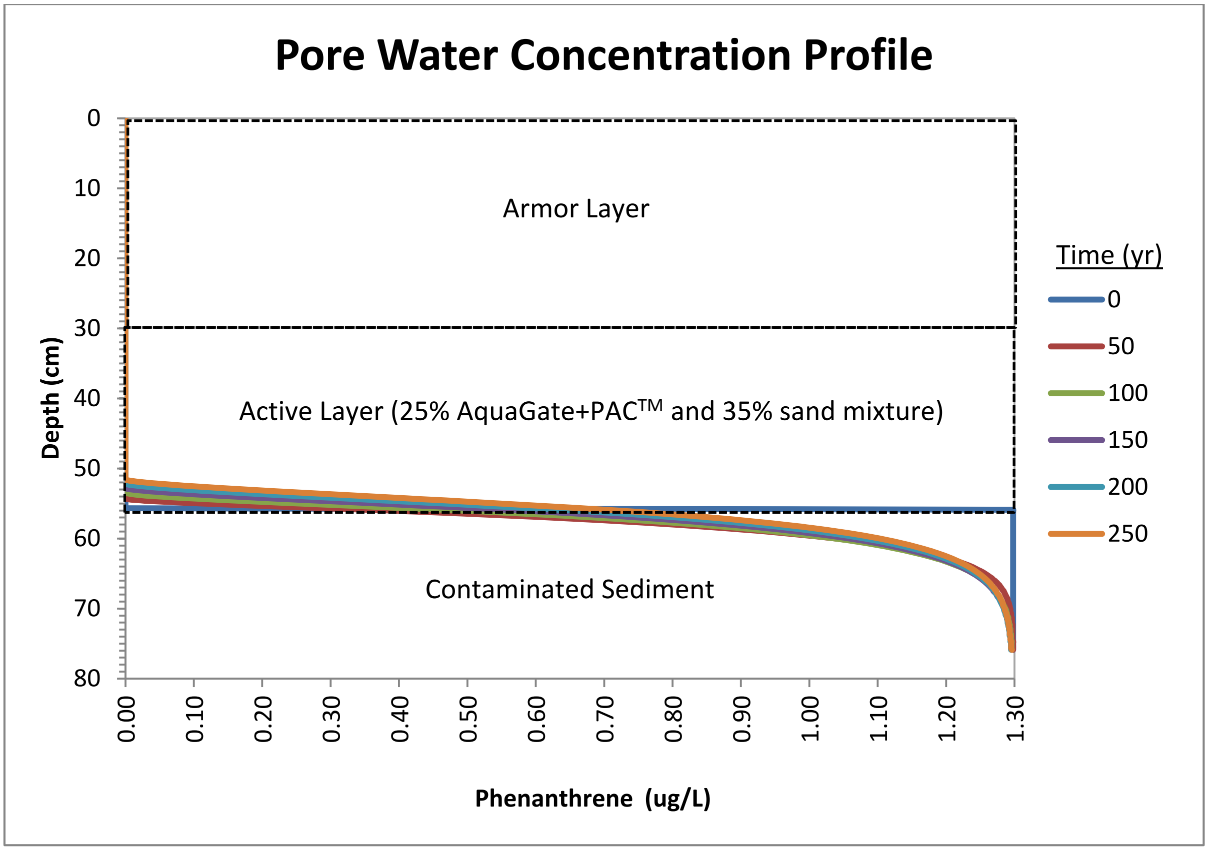
Active Layer Details: Mixture of 25% (v/v) AquaGate+PAC™ (with 10% AC) and 75% (v/v) sand

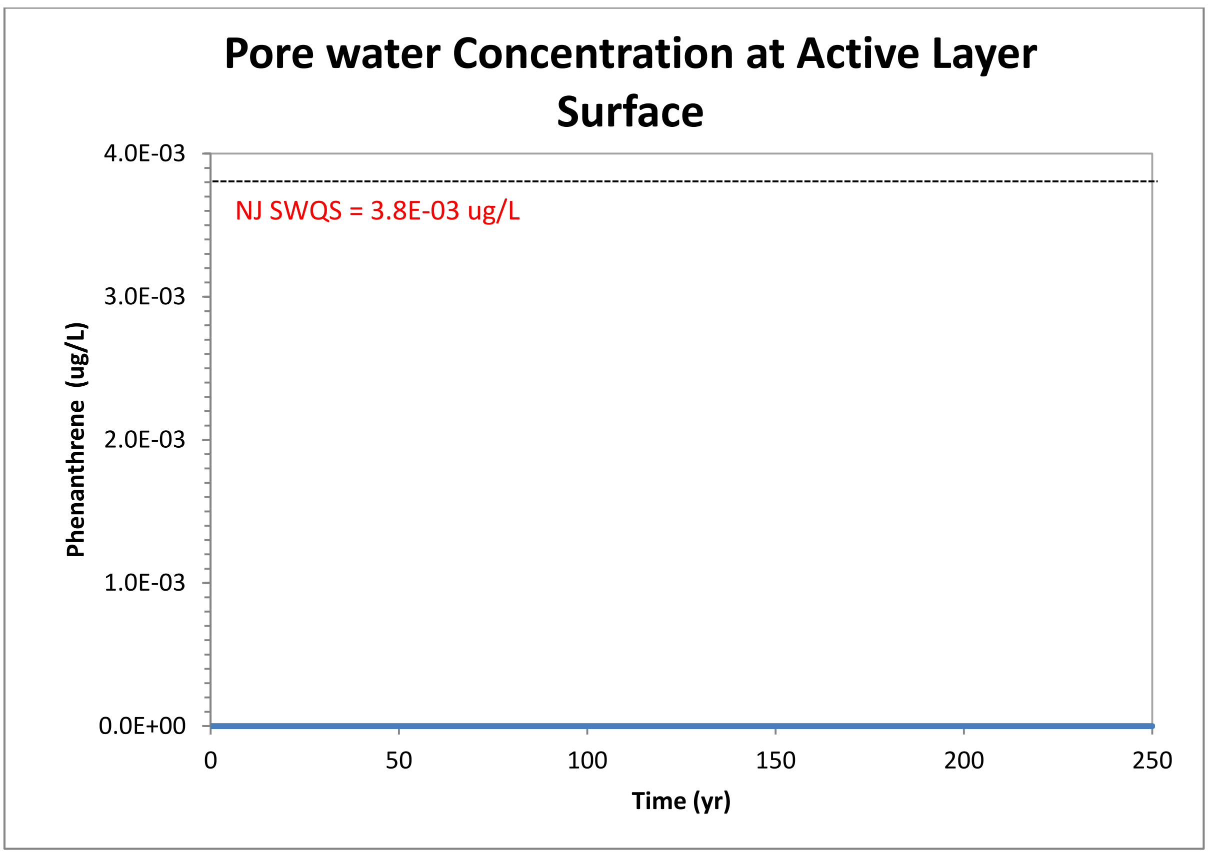
Cap Layers Properties	Active Layer (Activated Carbon/ Sand Mixture)	Underlying Native Sediment
Thickness (cm)	25.4 (10 inches)	NA
Active Material	Activated Carbon (AquaGate+PAC™)	Native Sediment
Bulk density (g/cm3)	0.026 (bulk density of activated carbon fraction in mixture)	1.6
Porosity (weighted average of mixture)[1]	0.363	0.65
Sorption Isotherm	Freundlich	Linear-$K_{oc}f_{oc}$
Activated Carbon Freundlich K_f coefficient[2]	1.65E+06	NA
Activated Carbon Freundlich N coefficient[2]	0.41	NA
Organic carbon fraction[3] (foc)	NA	0.056
Hydrodynamic dispersivity[4] (average), cm	2.76	2.76

Notes:
NA = Not applicable
[1] US Department of Energy (2009). PNNL-18801, September, p. 2.1.
[2] Walters & Luthy, 1984. ES&T, Vol.18, No.6, p 395-403.
[3] Site specific average value for the 2.5'-3.5' bgs sediment interval.
[4] Calculated value provided by Dr. Danny Reible based upon site specific upwelling velocity and tidal fluctuations.

Breakthrough Criteria: New Jersey Surface Water Quality Standards (NJSWQS). NJAC 7:9B Fresh Water (FW2) Criteria for Human Health.

NJ SWQS criterion for Phenanthrene = 3.8×10^{-3} µg/L (No NJSWQS available for phenanthrene, therefore value for benzo(a)pyrene was used)


Pore Water Concentration Profile
Armor Layer
Active Layer (25% AquaGate+PAC™ and 35% sand mixture)
Contaminated Sediment
Depth (cm)
0
10
20
30
40
50
60
70
80
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
Phenanthrene (ug/L)
Time (yr)
0
50
100
150
200
250


Pore water Concentration at Active Layer Surface
NJ SWQS = 3.8E-03 ug/L
Phenanthrene (ug/L)
4.0E-03
3.0E-03
2.0E-03
1.0E-03
0.0E+00
0
50
100
150
200
250
Time (yr)

ATTACHMENT 2

Draft Data Report Lower Passaic River Seepage Survey
April 2013
Coastal Monitoring Associates, LLC

Draft Data Report

Lower Passaic River Seepage Survey

April 2013

Submitted to:

CH2M HILL

One South Main Street, Suite 1100

Dayton, OH 45402

Submitted by:

Coastal Monitoring Associates, LLC

4741 Orchard Ave.

San Diego, CA 92107

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LIST OF ACRONYMS

DGPS	Differential Global Positioning System
FS	Full Scale
GPS	Global Positioning System
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
SOP	Standard Operating Procedure

UNITS

V	volts
cm	centimeters
cm/day	centimeters per day
ml/min	milliliters per minute

LIST OF FIGURES

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1 INTRODUCTION

1.1 BACKGROUND

This data report describes the results of a seepage measurement study on the Lower Passaic River near Lyndhurst, New Jersey. The work was performed by Coastal Monitoring Associates under a sub-contract to CH2M Hill, Inc.

1.2 SITE CHARACTERISTICS

The study area was located at the Lower Passaic River Restoration Project Study Area on the Lyndhurst section of the Lower Passaic River. This portion of the river is freshwater, but tidally influenced. The area where the measurements were conducted was along the eastern shore in shallow water characterized by soft sediment and mudflats.

1.3 OBJECTIVES OF THE PROJECT

The objectives for this work were to collect seepage rate measurements for a complete tidal cycle at four target stations within the designated study area.

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2 PROJECT TECHNOLOGY AND METHODOLOGY

2.1 SEEPAGE MEASUREMENTS

The Ultra Seep system was used to quantify seepage rates at the site. The Ultra Seep technology (Figure 2-1 and Figure 2-2) is based on the time-transient ultrasonic groundwater seepage meter described by Paulsen et al (2001). For this study, the systems were used only to measure flow, and the data produced were time series of groundwater discharge.

The ultrasonic flow sensor uses two piezoelectric transducers to continuously measure the travel times of ultrasonic waves along the flow path of the seepage water through the flow tube. As water enters the flow tube, it passes through the ultrasonic beam path. The ultrasonic signal that travels with the flow has a shorter travel time than the signal traveling against flow. The perturbation of travel time is directly proportional to the velocity of flow in the tube. The UltraSeep meter relies on a stainless steel, open-bottomed chamber measuring 122 cm in diameter to funnel the seepage water to the flow sensor. The flow sensor is connected to the funnel via 12 mm Teflon tubing, allowing free flow of water between the funnel and the outside environment. Data from the flow meter were monitored by an integrated data logger/controller unit. All of UltraSeep components, along with a 12 V submersible battery housing, are mounted within a 72 cm diameter by 58 cm high cylindrical stainless steel frame.

Prior to the deployments, the flow meters were calibrated using a highly-accurate, low-flow peristaltic pump. Five flow rates are run through the flow meter, generally ranging from about -10 ml/min to +10 ml/min. For the deployments, the sampling station was located using the sub-meter GPS. The UltraSeep meter was lowered to the bottom directly from the survey boat. Once the unit was settled on the bottom, the seal was checked. Care was taken to assure that any air that may have been trapped in the funnel or the flow tube had been purged by flushing with a hand-held purge bulb and checking the aeration reading on the flow meter output. Flow data was then logged for a period of approximately 48 hours. At the end of each deployment, the valves to the flow meter were left closed for a period of about 1 hour to check the zero-flow condition. At the end of the deployment, the meter was recovered using a lift line to the survey boat.

The seepage measurements were conducted in accordance with the UltraSeep SOP. Seepage measurements were performed at two pre-determined stations (PW-A3 and PW-B3). At each station, the following data were recorded:

- Station identification
- Date and time
- Deployment coordinates
- Depth of water
- Bottom type
- Hourly-average specific discharge rate
- Hourly standard deviation of specific discharge rate
- 24-Hour average specific discharge rate
- Deployment period
- River elevation (from level logger)

Figure 2-1. The UltraSeep system used to quantify groundwater discharge at the Lower Passaic River site.

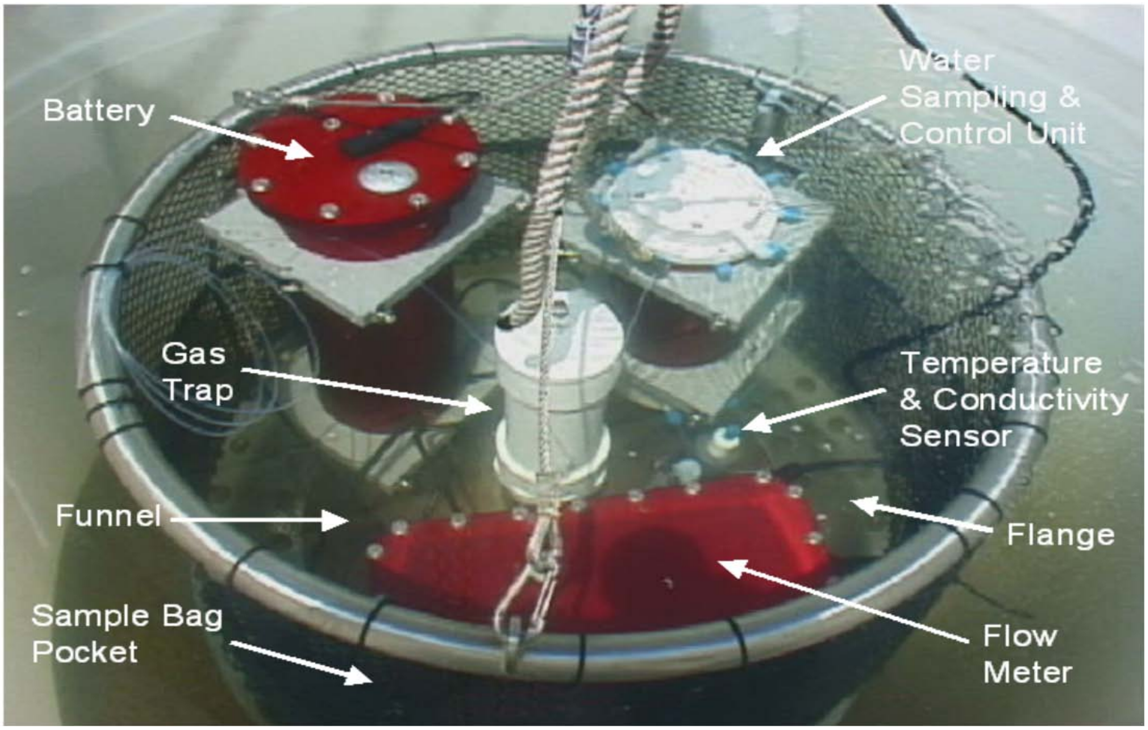

Figure 2-2. Component view of the commercial UltraSeep showing the water sampling and control unit, battery housing, flow meter, gas trap, funnel, and sensors.

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3 RESULTS

3.1 DATA QUALITY RESULTS

The quality assurance (QA) objective of this field investigation was to collect data of known and appropriate quality for the project objectives. The QA processes included the application of: (1) appropriate field techniques; (2) appropriate analytical methods; and (3) measurement objectives for precision, accuracy, representativeness, completeness, and comparability (PARCC). Results for the QA objectives for the UltraSeep measurements are summarized below.

3.1.1 ULTRASEEP DATA QUALITY

Precision

Precision for the UltraSeep flow sensors was assessed on the basis of replicate analysis performed under controlled laboratory conditions prior to commencement of the survey. Sensor replicates for the flow meter consisted of a minimum of 120 individual measurements for each standard flow rate. Results for the UltraSeep flow meter laboratory precision were generated for replicate measurements of five separate flow rates using a high-precision, calibrated, peristaltic pump. Laboratory relative standard deviations (RSDs) for the UltraSeep flow meters was always less than 10%, ranging from 3 - 6% of full scale for US1, 5 – 7% for US2, 4 – 8% for US3, and 4 – 9% for US4 (Table 3-1 through Table 3-4). This range of variation is typical for the extremely low flow range required for measuring groundwater discharge.

Accuracy

For UltraSeep flow, accuracy was established by applying laboratory calibrations. Calibration curves for the flow meters are shown in Figure 3-1 through Figure 3-4. Based on the calibrations, accuracy (RPD) was always less than 5%, ranging from 0 - 3% of full scale for US1, 1 – 2% for US2, 1 – 2% for US3, and 1 – 4% for US4 (Table 3-1 through Table 3-3.

Representativeness

Representativeness is an expression of the degree to which sample data accurately represent the characteristics of a population, parameter variations at a sampling point, or an environmental condition that they are intended to represent. Representativeness was maximized by (1) selecting the appropriate number of samples and sampling locations, and (2) using appropriate and established sample collection, handling, and analysis techniques to provide information that reflects actual site conditions.

Completeness

Completeness assesses the amount of valid data obtained from a measurement system compared to the amount of data required to achieve a particular statistical level of confidence. The percent completeness was calculated as the number of stations yielding acceptable data divided by the total number of stations planned to be collected and multiplied by 100. Results for completeness were assessed for the UltraSeep data based on the number of stations where acceptable data was collected. Completeness for the UltraSeep data was 100% for the required 24-hour tidal cycle periods.

Comparability

Comparability is a qualitative parameter that expresses the degree of confidence that one data set may be compared to another. This goal was achieved through the use of (1) standardized techniques to collect and analyze samples, and (2) appropriate units to report analytical results. The comparability of the data was maximized by using standard analytical methods when possible, reporting data in consistent units, reporting data in a tabular format, and by validating the results against commonly accepted methodologies and target limits.

Condition	Pump	Flow Meter		Cal Flow Meter		
	Vel (ml/min)	Vel (ml/min)	Stdev (ml/min)	Vel (ml/min)	RSD (%)	RPD (%)
Mid Pos	8.00	8.45	0.32	8.01	4%	0%
Low Pos	4.55	4.24	0.27	4.57	6%	0%
Zero	0.00	-1.47	0.29	-0.12	-	-
Low Neg	-5.00	-7.24	0.28	-4.85	6%	3%
Mid Neg	-9.00	-12.38	0.31	-9.06	3%	1%

Slope =	0.820
Intercept=	1.09
R^2=	1.00
Kc=	-18.04%

Table 3-1. Flow calibration for the US1 UltraSeep deployed at station 1. Flows reported in milliliters per minute (ml/min) and relative standard deviations and percent differences reported as percent of full scale (%FS).

Condition	Pump	Flow Meter		Cal Flow Meter		
	Vel (ml/min)	Vel (ml/min)	Stdev (ml/min)	Vel (ml/min)	RSD (%)	RPD (%)
Mid Pos	9.00	15.33	0.42	9.11	5%	1%
Low Pos	5.00	10.52	0.36	4.90	7%	2%
Zero	0.00	4.85	0.27	-0.06	-	-
Low Neg	-4.55	-0.35	0.33	-4.62	7%	1%
Mid Neg	-8.00	-4.09	0.32	-7.89	4%	1%

Slope =	0.875
Intercept=	-4.31
R^2=	1.00
Kc=	-12.46%

Table 3-2. Flow calibration for the US2 UltraSeep deployed at station 2. Flows reported in milliliters per minute (ml/min) and relative standard deviations and percent differences reported as percent of full scale (%FS).

Condition	Pump	Flow Meter		Cal Flow Meter		
	Vel (ml/min)	Vel (ml/min)	Stdev (ml/min)	Vel (ml/min)	RSD (%)	RPD (%)
Mid Pos	9.00	11.29	0.34	9.09	4%	1%
Low Pos	5.00	6.35	0.38	4.88	8%	2%
Zero	0.00	0.66	0.29	0.02	-	-
Low Neg	-4.55	-4.75	0.28	-4.59	6%	1%
Mid Neg	-8.00	-8.69	0.33	-7.95	4%	1%

Slope =	0.85
Intercept=	-0.54
R^2=	1.00
Kc=	-14.72%

Table 3-3. Flow calibration for the US3 UltraSeep deployed at station 3. Flows reported in milliliters per minute (ml/min) and relative standard deviations and percent differences reported as percent of full scale (%FS).

Condition	Pump	Flow Meter		Cal Flow Meter		
	Vel (ml/min)	Vel (ml/min)	Stdev (ml/min)	Vel (ml/min)	RSD (%)	RPD (%)
Mid Pos	9.00	10.26	0.34	9.12	4%	1%
Low Pos	5.00	5.65	0.43	4.82	9%	4%
Zero	0.00	0.53	0.37	0.04	-	-
Low Neg	-4.55	-4.45	0.39	-4.60	9%	1%
Mid Neg	-8.00	-8.03	0.47	-7.94	6%	1%

Slope =	0.93
Intercept=	-0.45
R^2=	1.00
Kc=	-6.76%

Table 3-4. Flow calibration for the US4 UltraSeep deployed at station 4. Flows reported in milliliters per minute (ml/min) and relative standard deviations and percent differences reported as percent of full scale (%FS).

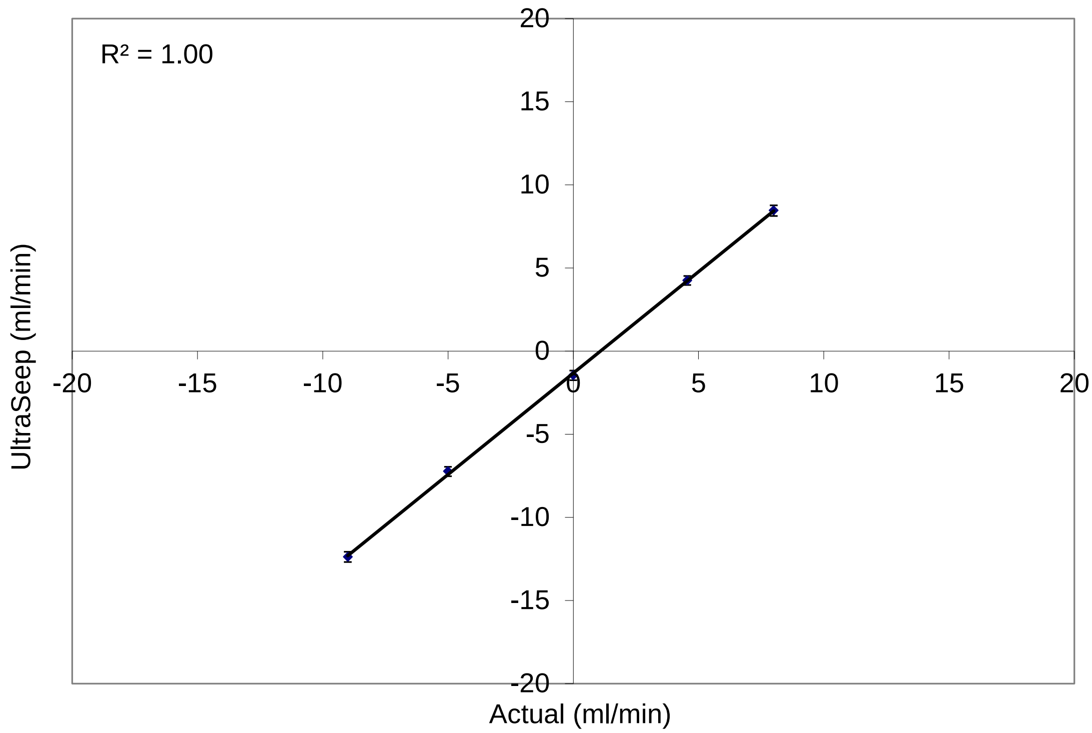

Figure 3-1. Flow meter calibration for the UltraSeep US1.

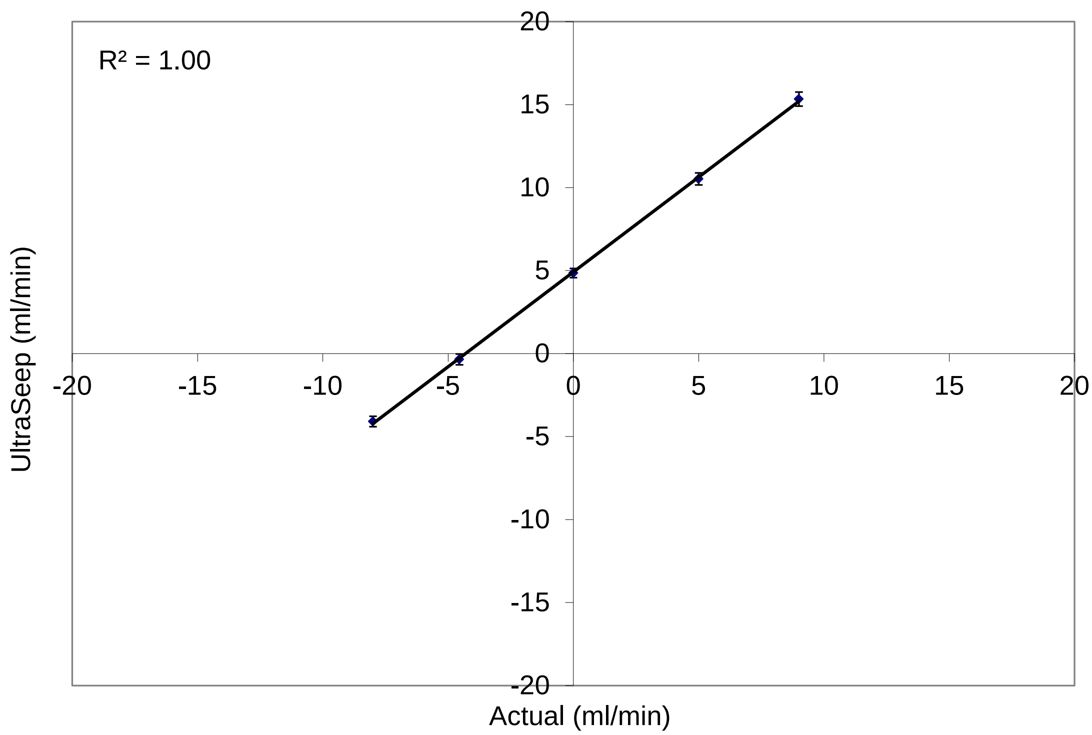

Figure 3-2. Flow meter calibration for the UltraSeep US2.

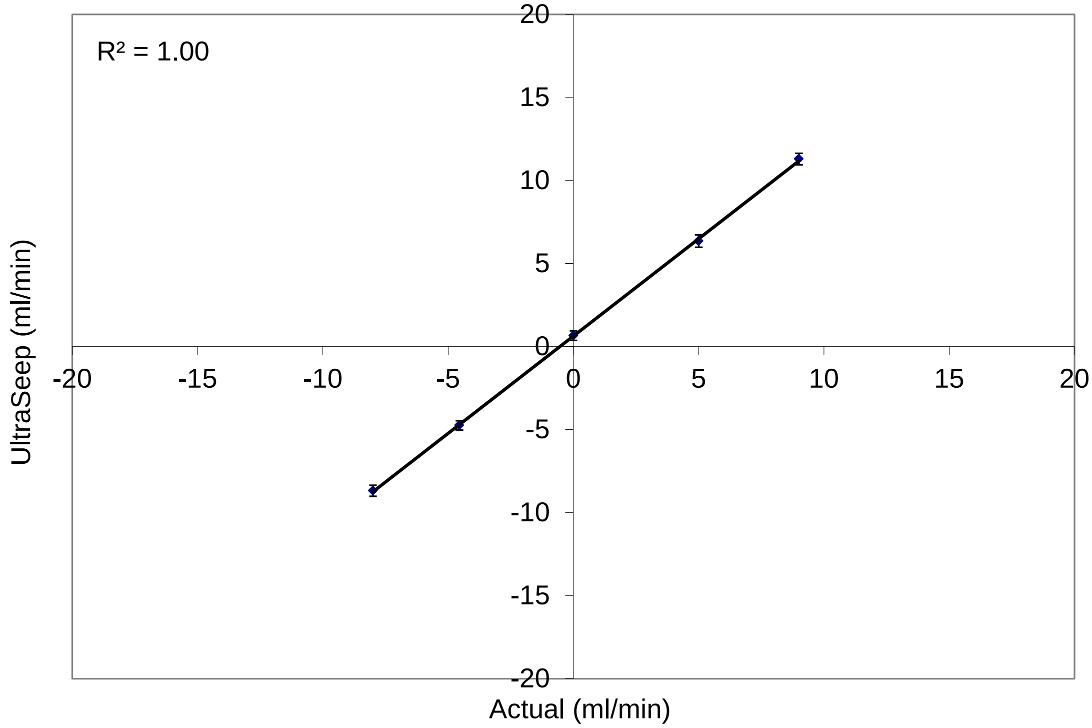

Figure 3-3. Flow meter calibration for the UltraSeep US3.

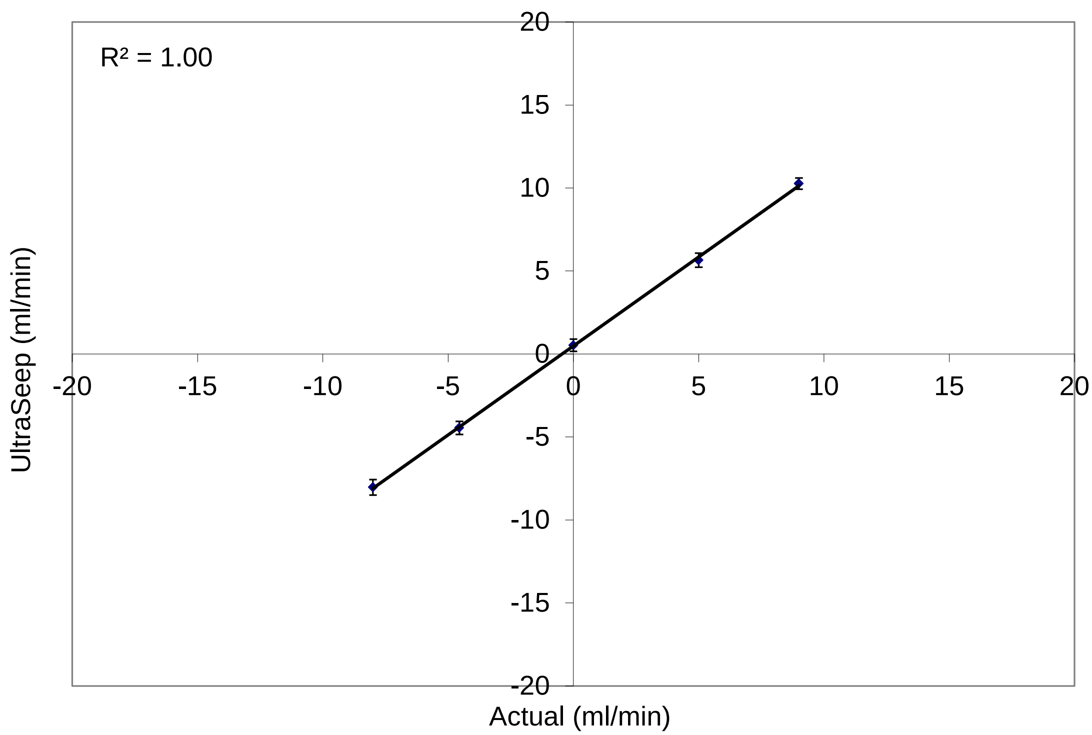

Figure 3-4. Flow meter calibration for the UltraSeep US4.

3.2 SEEPAGE MEASUREMENT RESULTS

UltraSeep seepage measurements were successfully collected at the 4 target stations. Results are summarized in Table 3-5 through Table 3-9 and Figure 3-5 through Figure 3-8 below. Hourly specific discharge rates were averaged over 24-hour windows (which is close to the tide period) to estimate tidally averaged specific discharge. Tidally averaged specific discharge ranged from a low of 0.07 cm/day at Station 3 to a high of 2.56 cm/day at Station 2. All stations showed discernible tidal fluctuations in specific discharge, and particularly at Station 1 and Station 2. Maximum discharge generally occurred during the falling limb of the tide.

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Station Information							Field Notes	
Sampling Location	Deployment Date-Time	Retrieval Date-Time	Water Depth (ft)	Latitude (degrees N NAD83)	Longitude (degrees W NAD83)	DGPS Accuracy (cm)	Sediment Type	General Notes
Station 1	4/8/2013 13:17	4/12/2013 12:45	4.0	40.81727127	74.13669039	96.00	Soft Silt	Meter US1. Installed to full depth of flange.
Station 2*	4/11/2013 17:40	4/13/2013 12:20	3.0	40.81799051	74.13604323	76.00	Soft Silt	Meter US2. Installed to full depth of flange.
Station 3	4/8/2013 11:46	4/12/2013 11:08	3.5	40.81835042	74.13495621	87.00	Soft Silt	Meter US3. Installed to full depth of flange.
Station 4	4/8/2013 11:13	4/13/2013 11:32	6.0	40.81873324	74.13378554	77.00	Soft Silt	Meter US4. Installed to full depth of flange.

*Meter at station 2 was reinstalled further from shore due to shallow water

Table 3-5. Station information and field notes for the UltraSeep deployments.

Date-Time	Specific Discharge (cm/d)	Standard Deviation (cm/d)	Notes
4/8/13 14:42	-0.02	0.04	Pre-deployment zero
4/9/13 15:29	1.71	0.62	
4/9/13 16:29	0.60	0.46	
4/9/13 17:29	-0.82	0.42	
4/9/13 18:29	-1.47	0.22	
4/9/13 19:29	-1.57	0.13	
4/9/13 20:29	-1.07	0.27	
4/9/13 21:29	-0.17	0.29	
4/9/13 22:29	0.74	0.36	
4/9/13 23:29	1.92	0.30	
4/10/13 0:29	2.50	0.19	
4/10/13 1:29	2.49	0.19	
4/10/13 2:29	2.14	0.23	
4/10/13 3:29	1.78	0.37	
4/10/13 4:29	0.97	0.59	
4/10/13 5:29	-0.12	0.06	
4/10/13 6:29	-1.35	0.34	
4/10/13 7:29	-1.61	0.13	
4/10/13 8:29	-1.38	0.14	
4/10/13 9:29	-0.79	0.21	
4/10/13 10:29	0.19	0.40	
4/10/13 11:29	1.24	0.66	
4/10/13 12:29	2.18	0.17	
4/10/13 13:29	2.41	0.14	
4/10/13 14:29	2.11	0.17	
4/11/13 16:41	0.02	0.04	Post-deployment zero

24-hour Average	0.53
Minimum	-1.61
Maximum	2.50
Stdev	1.50

Table 3-6. Specific discharge results for Station 1.

Date-Time	Specific Discharge (cm/d)	Standard Deviation (cm/d)	Notes
4/11/13 18:07	-0.07	0.04	Pre-deployment zero
4/12/13 7:29	1.89	0.38	
4/12/13 8:29	1.12	0.51	
4/12/13 9:29	0.11	0.37	
4/12/13 10:29	-0.22	0.29	
4/12/13 11:29	0.80	0.53	
4/12/13 12:29	1.41	1.40	
4/12/13 13:29	3.70	1.30	
4/12/13 14:29	5.73	0.70	
4/12/13 15:29	6.46	0.66	
4/12/13 16:29	4.93	0.38	
4/12/13 17:29	4.40	0.52	
4/12/13 18:29	1.03	0.91	
4/12/13 19:29	1.54	0.21	
4/12/13 20:29	0.70	0.64	
4/12/13 21:29	-0.28	0.15	
4/12/13 22:29	0.22	0.16	
4/12/13 23:29	0.19	0.12	
4/13/13 0:29	0.88	0.41	
4/13/13 1:29	3.50	0.87	
4/13/13 2:29	6.17	0.63	
4/13/13 3:29	5.77	0.51	
4/13/13 4:29	5.02	0.39	
4/13/13 5:29	4.34	0.38	
4/13/13 6:29	2.05	1.24	
4/13/13 11:28	0.04	0.05	Post-deployment zero
24-hour Average	2.56		
Minimum	-0.28		
Maximum	6.46		
Stdev	2.27		

Table 3-7. Specific discharge results for Station 2.

Date-Time	Specific Discharge (cm/d)	Standard Deviation (cm/d)	Notes
4/8/13 10:11	0.00	0.04	Pre-deployment zero
4/8/13 13:11	0.11	0.03	
4/8/13 13:11	0.11	0.03	
4/8/13 13:11	0.11	0.03	
4/8/13 13:11	0.11	0.03	
4/8/13 13:11	0.08	0.03	
4/8/13 13:11	0.04	0.04	
4/8/13 13:11	0.02	0.04	
4/8/13 13:11	0.03	0.04	
4/8/13 13:11	0.03	0.03	
4/8/13 13:11	0.02	0.04	
4/8/13 13:11	0.07	0.04	
4/8/13 13:11	0.11	0.03	
4/8/13 13:11	0.12	0.03	
4/8/13 13:11	0.11	0.03	
4/8/13 13:11	0.11	0.03	
4/8/13 13:11	0.07	0.04	
4/8/13 13:11	0.07	0.03	
4/8/13 13:11	0.11	0.04	
4/8/13 13:11	0.11	0.03	
4/8/13 13:11	0.04	0.03	
4/8/13 13:11	-0.01	0.04	
4/8/13 13:11	-0.02	0.04	
4/8/13 13:11	0.00	0.04	
4/8/13 13:11	0.06	0.04	
4/11/13 15:01	0.01	0.03	Post-deployment zero

24-hour Average	0.07
Minimum	-0.02
Maximum	0.12
Stdev	0.04

Table 3-8. Specific discharge results for Station 3.

Date-Time	Specific Discharge (cm/d)	Standard Deviation (cm/d)	Notes
4/11/13 17:12	-0.01	0.04	Pre-deployment zero
4/11/13 18:51	-0.23	0.17	
4/11/13 19:51	-0.33	0.07	
4/11/13 20:51	-0.22	0.07	
4/11/13 21:51	-0.05	0.08	
4/11/13 22:51	0.14	0.06	
4/11/13 23:51	0.28	0.08	
4/12/13 0:51	0.54	0.11	
4/12/13 1:51	0.77	0.12	
4/12/13 2:51	0.78	0.15	
4/12/13 3:51	0.69	0.14	
4/12/13 4:51	0.56	0.18	
4/12/13 5:51	0.26	0.11	
4/12/13 6:51	-0.20	0.16	
4/12/13 7:51	-0.45	0.11	
4/12/13 8:51	-0.45	0.06	
4/12/13 9:51	-0.26	0.09	
4/12/13 10:51	-0.10	0.09	
4/12/13 11:51	0.10	0.08	
4/12/13 12:51	0.22	0.08	
4/12/13 13:51	0.46	0.11	
4/12/13 14:51	0.66	0.12	
4/12/13 15:51	0.64	0.13	
4/12/13 16:51	0.57	0.25	
4/12/13 17:51	0.48	0.14	
4/13/13 10:50	0.04	0.04	Post-deployment zero

24-hour Average	0.20
Minimum	-0.45
Maximum	0.78
Stdev	0.41

Table 3-9. Specific discharge results for Station 4.

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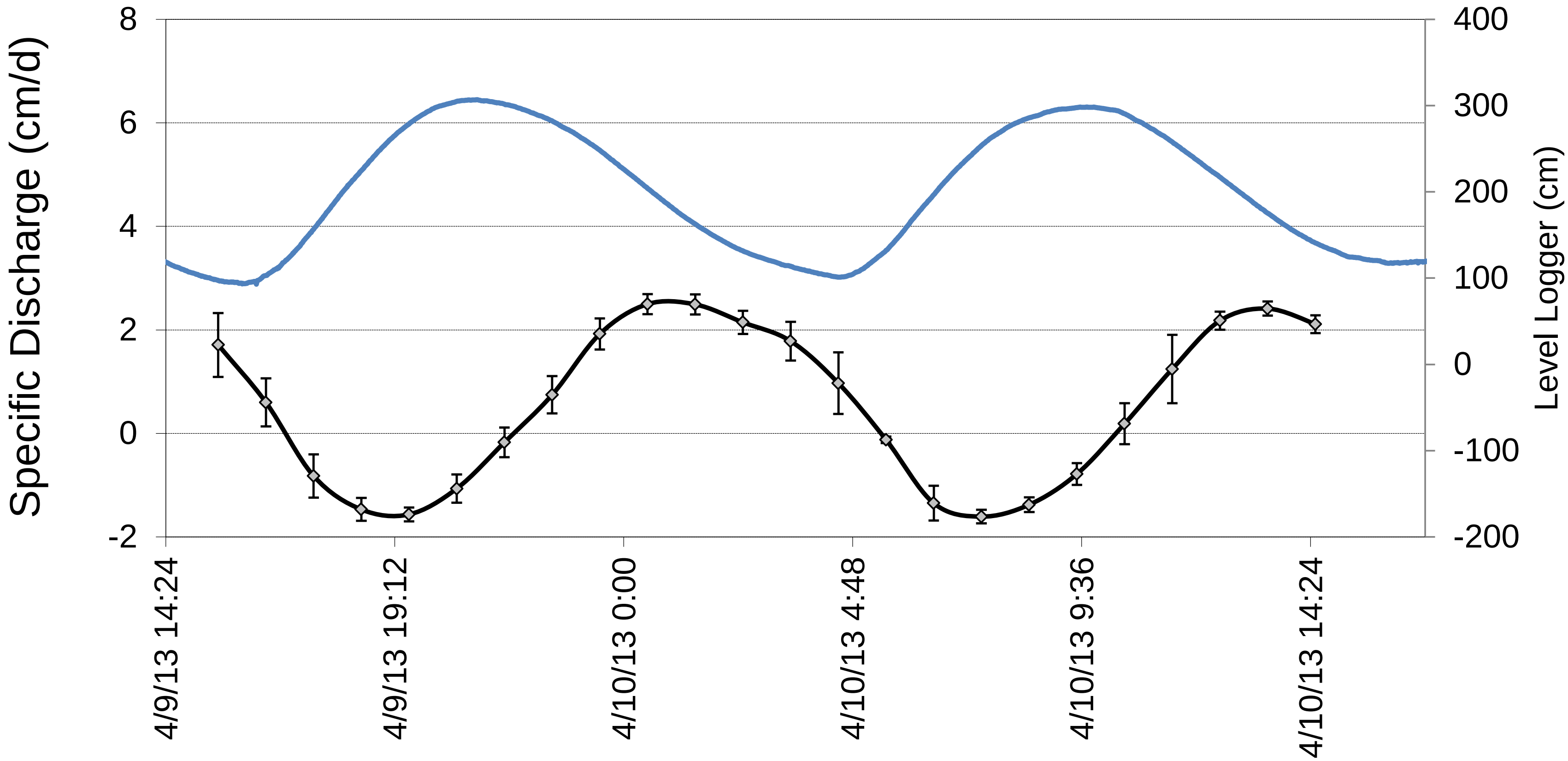

Figure 3-5. Time series of specific discharge at Station 1. Black line is specific discharge and blue line is relative water level from the level logger deployed at Station 4. Error bars represent standard deviations of specific discharge for each 1 hour measurement period.

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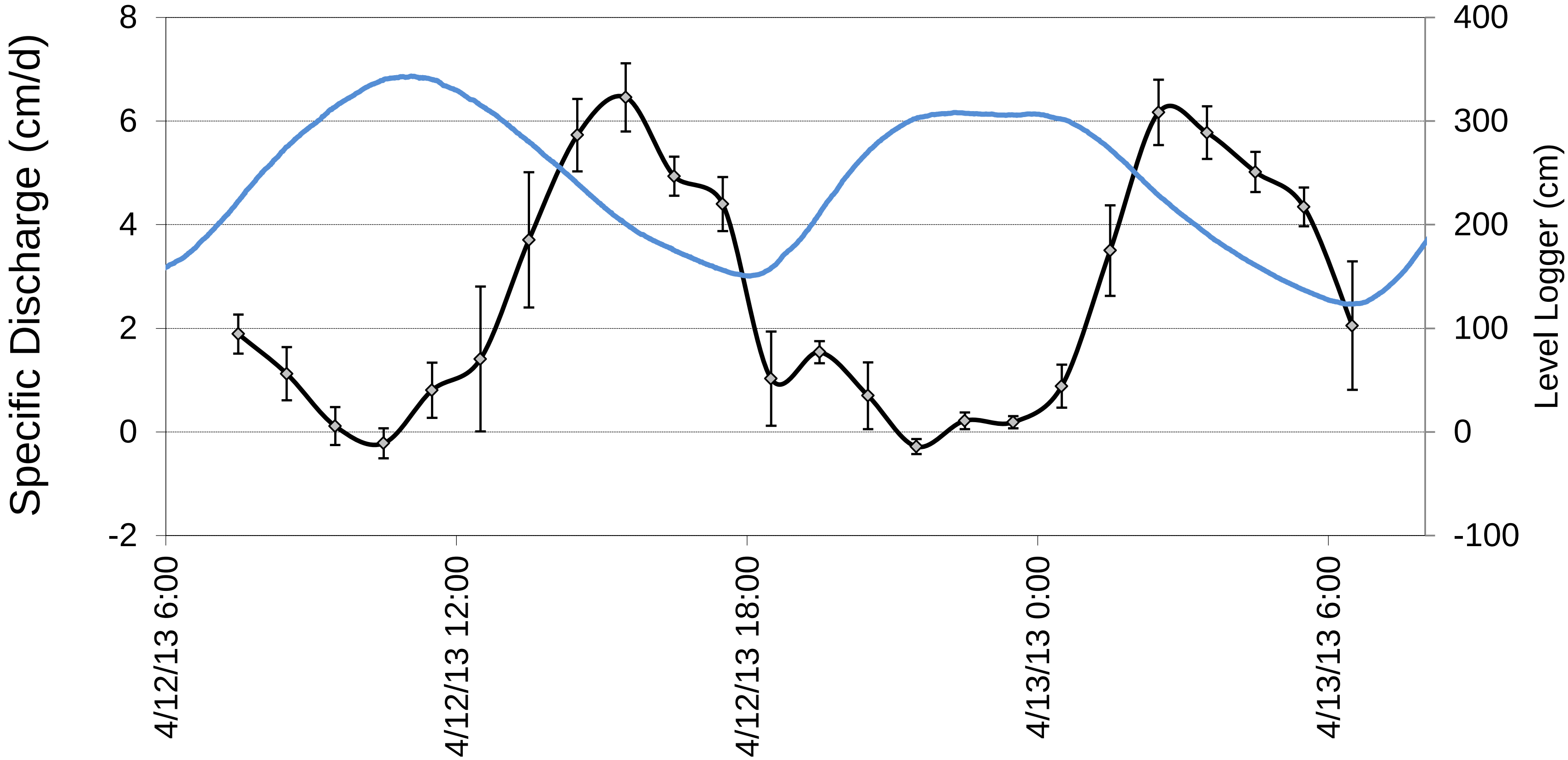

Figure 3-6. Time series of specific discharge at Station 2. Black line is specific discharge and blue line is relative water level from the level logger deployed at Station 4. Error bars represent standard deviations of specific discharge for each 1 hour measurement period.

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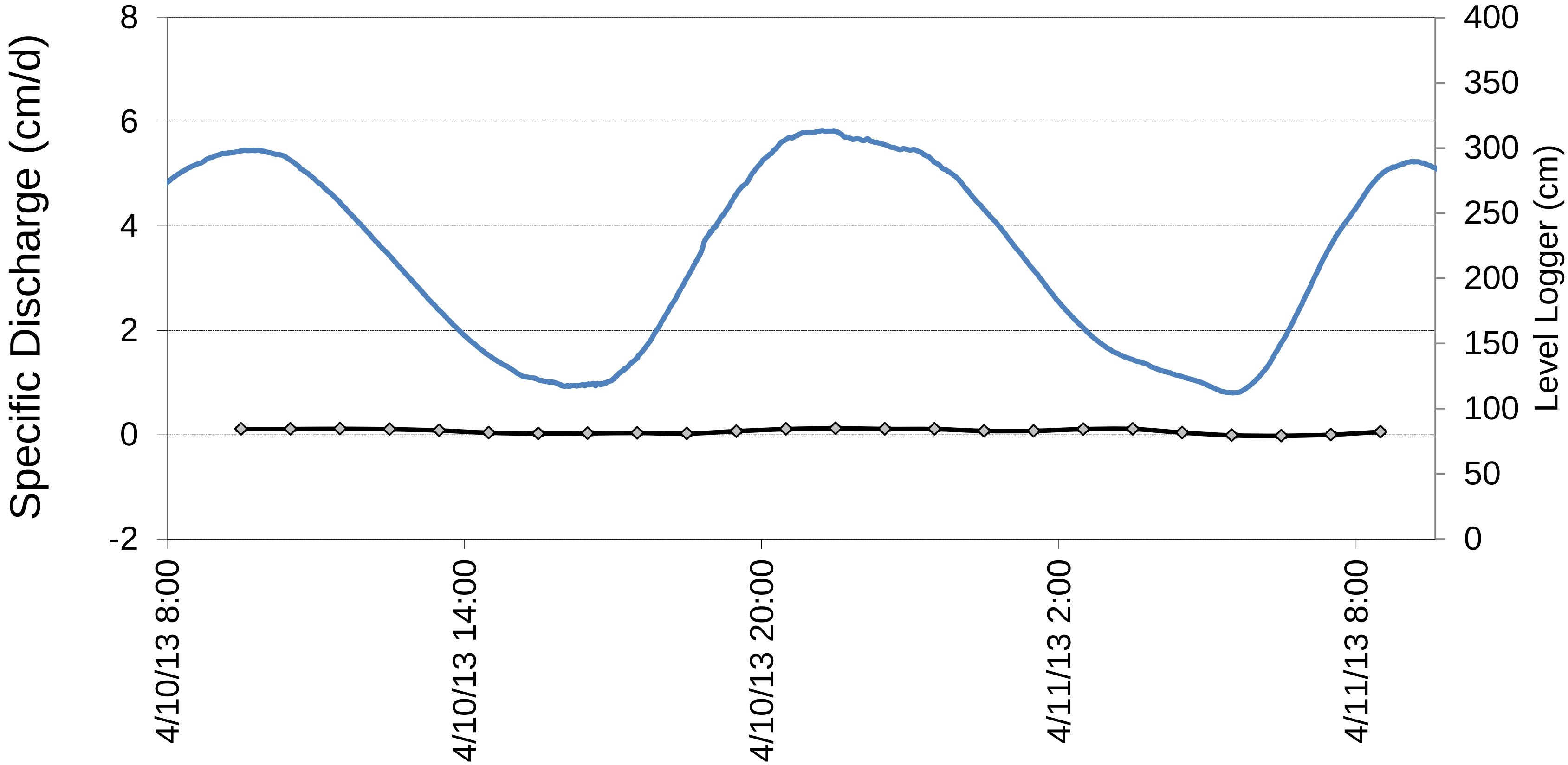

Figure 3-7. Time series of specific discharge at Station 3. Black line is specific discharge and blue line is relative water level from the level logger deployed at Station 4. Error bars represent standard deviations of specific discharge for each 1 hour measurement period.

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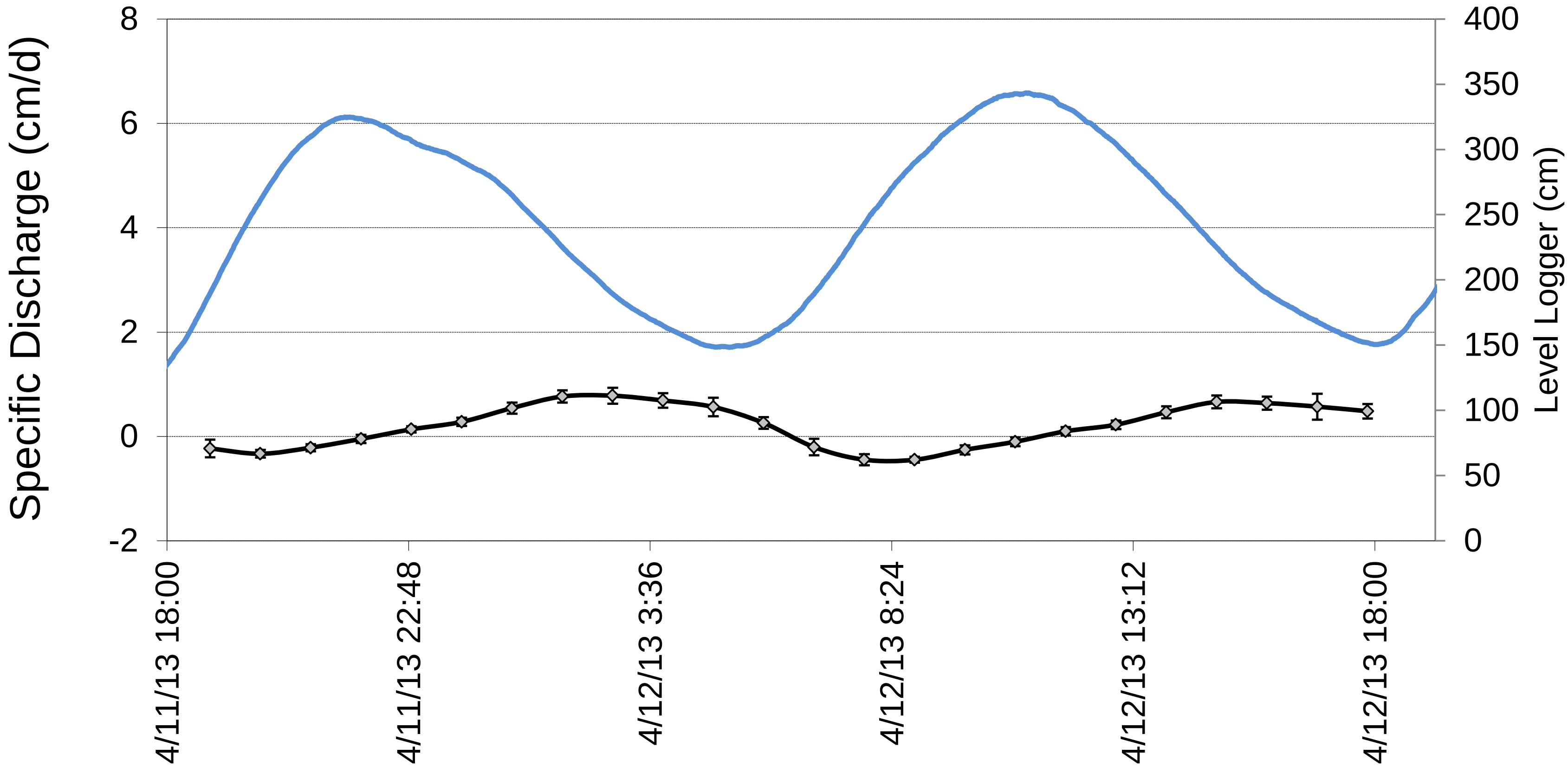


Figure 3-8. Time series of specific discharge at Station 4. Black line is specific discharge and blue line is relative water level from the level logger deployed at Station 4. Error bars represent standard deviations of specific discharge for each 1 hour measurement period.

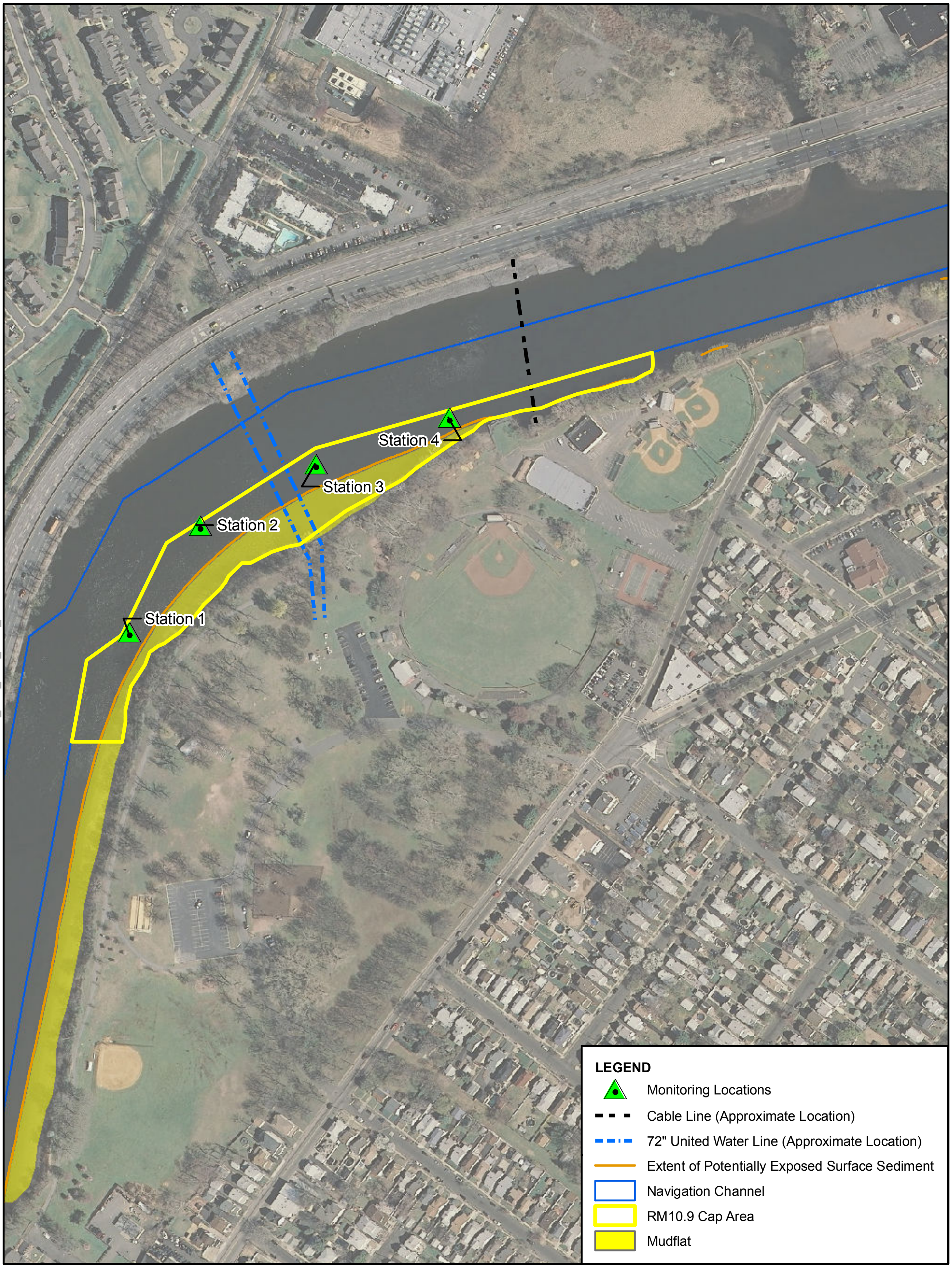
References

Chadwick, D.B., J. Groves, C. Smith, and R. Paulsen. 2003. Hardware description and sampling protocols for the Trident Probe and UltraSeep system: Technologies to evaluate contaminant transfer between groundwater and surface water. Technical Report #1902, SSC San Diego, United States Navy.

Chadwick, B. and A. Hawkins, 2008. Monitoring of Water and Contaminant Migration at the Groundwater–Surface Water Interface (ER200422) - Final Report, SPAWAR Systems Center San Diego Technical Report 1967.

Paulsen, R.J., C. F. Smith, D. O'Rourke and T. Wong, 2001. Development and Evaluation of an Ultrasonic Groundwater Seepage Meter, Ground Water Nov-Dec 2001, 904-911.

DAY V:\LOWERPASSAICRIVERGRP\412305LOWERPASSAICFS\GIS\MAPFILES\RM10-9\BODR\FIG4-5_LPR_10-9_UTIL_OUTFALL.MXD ECLARK1 4/23/2013 3:32:17 PM



N

0 50 100 200 300 Feet

Notes:
1. Orthophoto: NJGIS, 2007
2. The Extent of Potentially Exposed Surface Sediment was generated from the -2ft (NGVD29) elevation, which represents the Mean Low Water for this part of the river. The data source was the July 2011 Bathymetry Survey conducted as part of the RM 10.9 Characterization Program (CH2M HILL & AECOM, 2012).

Seepage Meter Locations

RM 10.9 Removal Area

Lower Passaic River Study Area, New Jersey

CH2MHILL

ATTACHMENT 3

Site-Specific Composite Pore Water Analytical Data

			COMP 1		Duplicate of COMP 1		COMP 2		Duplicate of COMP 2		COMP 3		Duplicate of COMP 3	
		Field Sample ID	LPR-RM10.9D-COMP1-PWS		LPR-RM10.9D-COMP1-PWT, LPR-RM10.9D-COMP-PWT		LPR-RM10.9D-COMP2-PWS		LPR-RM10.9D-COMP2-PWT		LPR-RM10.9D-COMP3-PWS		LPR-RM10.9D-COMP3-PWT	
		Date	3/8/2013 12:30		3/8/2013 12:30		3/15/2013 12:30		3/15/2013 12:30		3/22/2013 11:10		3/22/2013 11:10	
Method	Analyte	Unit	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
CARB429 MOD	1-Methylnaphthalene	ng/l	324		313		333		336		402			
CARB429 MOD	1-Methylphenanthrene	ng/l	469		455		477		447		570			
CARB429 MOD	2,3,5-Trimethylnaphthalene	ng/l	446	J	289	J	383		417		500			
CARB429 MOD	2,6-Dimethylnaphthalene	ng/l	212		190		258		257		333			
CARB429 MOD	2-Methylnaphthalene	ng/l	145		133		148		148		212			
CARB429 MOD	Acenaphthene	ng/l	293		277		330		323		390			
CARB429 MOD	Acenaphthylene	ng/l	83	J	55.6	J	89		87.3		95.6			
CARB429 MOD	Anthracene	ng/l	389		356		352		358		464			
CARB429 MOD	Benzo(a)anthracene	ng/l	713		691		684		733		754			
CARB429 MOD	Benzo(a)pyrene	ng/l	784		662		727		746		729			
CARB429 MOD	Benzo(b)fluoranthene	ng/l	783		822		762		747		784			
CARB429 MOD	Benzo(e)pyrene	ng/l	690	J	488	J	623		628		578			
CARB429 MOD	Benzo(g,h,i)perylene	ng/l	587		465	J	586		558		550			
CARB429 MOD	Benzo(k)fluoranthene	ng/l	390		321		343		369		353			
CARB429 MOD	Chrysene	ng/l	1460		1210		1360		1290		1320			
CARB429 MOD	Dibenzo(a,h)anthracene	ng/l	137		120	J	123		120		127			
CARB429 MOD	Dibenzothiophene	ng/l	238		220		160		163		253			
CARB429 MOD	Fluoranthene	ng/l	1950		1890		1860		1970		1960			
CARB429 MOD	Fluorene	ng/l	447		488		318		342		540			
CARB429 MOD	Indeno(1,2,3-cd)pyrene	ng/l	375		299	J	363		354		347			
CARB429 MOD	Naphthalene	ng/l	184		183		214		221		377			
CARB429 MOD	Perylene	ng/l	97.9		81.7		94.5		90.8		86.3			
CARB429 MOD	Phenanthrene	ng/l	1700		1690		685		757		1660			
CARB429 MOD	Pyrene	ng/l	1990		1900		1850		1960		1960			
CARB429 MOD	C1-Benzanthracene/chrysenes	ng/l	1690		1360		1580		1570		1590			
CARB429 MOD	C1-Dibenzothiophenes	ng/l	625		506		572		596		670			
CARB429 MOD	C1-Fluorenes	ng/l	616		567		614		624		720			
CARB429 MOD	C1-Phenanthrene/anthracenes	ng/l	2100		1670		1800		1810		2230			
CARB429 MOD	C1-Pyrene/fluoranthenes	ng/l	1690		1460		1610		1730		1600			
CARB429 MOD	C2-Benzanthracene/chrysenes	ng/l	1340		1080		1230		1290		1240			
CARB429 MOD	C2-Dibenzothiophenes	ng/l	1420		1050		1400		1390		1480			
CARB429 MOD	C2-Fluorenes	ng/l	1660		1360		1700		1680		1830			
CARB429 MOD	C2-Naphthalenes	ng/l	678		570		819		857		955			
CARB429 MOD	C2-Phenanthrene/anthracenes	ng/l	3380		2560		3460		3380		3500			
CARB429 MOD	C3-Benzanthracene/chrysenes	ng/l	726		589		675		709		648			
CARB429 MOD	C3-Dibenzothiophenes	ng/l	1840	J	1310	J	1790		1750		1780			
CARB429 MOD	C3-Fluorenes	ng/l	2120		1680		2170		2170		2370			
CARB429 MOD	C3-Naphthalene	ng/l	1250	J	884	J	1420		1490		1580			
CARB429 MOD	C3-Phenanthrene/anthracenes	ng/l	3600		2670		3630		3520		3510			
CARB429 MOD	C4-Benzanthracene/chrysenes	ng/l	465		389		447		447		434			
CARB429 MOD	C4-Dibenzothiophenes	ng/l	1220	J	841	J	1180		1210		1160			
CARB429 MOD	C4-Naphthalene	ng/l	2480	J	1600	J	2650		2690		2810			
CARB429 MOD	C4-Phenanthrenes/anthracenes	ng/l	2310	J	1620	J	2330		2280		2230			
E1630	Methyl Mercury (Dissolved)	ng/l	0.06		0.067		0.078							
E1630	Methyl Mercury (Total)	ng/l	69.7		83		40.7							
E1631E	Mercury (Dissolved)	ng/l	1.84	J	2.81	J	1.22							
E1631E	Mercury (Total)	ng/l	59700		45500		31300							
E1668A	PCB-1	ng/l	3.11		3.26		2.23	J	1.68	EMPC-J	3.42	J	3.39	J

E1668A	PCB-10	ng/l	2.39		2.85		2.27	J	2.67	EMPC-J	3.03	J	3.01	J
E1668A	PCB-100	ng/l		C93		C93		C93		C93		C93		C93
E1668A	PCB-101	ng/l		C90		C90		C90		C90		C90		C90
E1668A	PCB-102	ng/l		C98		C98		C98		C98		C98		C98
E1668A	PCB-103	ng/l	3.99		3.93		3.44	J	3.24	EMPC-J	2.78	EMPC-J	2.43	EMPC-J
E1668A	PCB-104	ng/l	<0.172	U	<0.125	U	<0.162	U	<0.487	U	<0.166	U	<0.173	U
E1668A	PCB-105	ng/l	206		194		182		163		135		129	
E1668A	PCB-106	ng/l	<0.137	U	<0.118	U	<0.152	U	<0.351	U	<0.151	U	<0.168	U
E1668A	PCB-107	ng/l	35.6		37.4		32.3		29.5		25.8		23.8	
E1668A	PCB-108	ng/l	18.8		19.4		17.5		16.4		14		13.1	
E1668A	PCB-109	ng/l		C86		C86		C86		C86		C86		C86
E1668A	PCB-11	ng/l	36.1		40.6		50.4		47.9		43.4		42.3	
E1668A	PCB-110	ng/l	470		415		459		568		399		360	
E1668A	PCB-111	ng/l	<0.162	U	<0.117	U	<0.152	U	<0.458	U	0.286	EMPC-J	0.257	EMPC-J
E1668A	PCB-112	ng/l	<0.176	U	<0.128	U	<0.165	U	<0.497	U	<0.169	U	<0.177	U
E1668A	PCB-113	ng/l		C90		C90		C90		C90		C90		C90
E1668A	PCB-114	ng/l	10.6		12.7		13.5		14		9.68		9.6	
E1668A	PCB-115	ng/l		C110		C110		C110		C110		C110		C110
E1668A	PCB-116	ng/l		C85		C85		C85		C85		C85		C85
E1668A	PCB-117	ng/l		C85		C85		C85		C85		C85		C85
E1668A	PCB-118	ng/l	542	J	563	J	480		446		355		334	
E1668A	PCB-119	ng/l		C86		C86		C86		C86		C86		C86
E1668A	PCB-12	ng/l	4.42		4.88		5.99		5.9	EMPC-J	5.86	J	5.82	J
E1668A	PCB-120	ng/l	0.594	EMPC-J	0.69		0.609	EMPC-J	0.782	EMPC-J	0.636	EMPC-J	0.619	EMPC-J
E1668A	PCB-121	ng/l	<0.168	U	<0.122	U	<0.158	U	<0.475	U	<0.161	U	<0.169	U
E1668A	PCB-122	ng/l	7.2		6.69	EMPC-J	7.8		6.94		5.98		5.25	
E1668A	PCB-123	ng/l	7.13	EMPC-J	7.69		8.16		9.17		7	J	6.79	J
E1668A	PCB-124	ng/l		C108		C108		C108		C108		C108		C108
E1668A	PCB-125	ng/l		C86		C86		C86		C86		C86		C86
E1668A	PCB-126	ng/l	15.1	EMPC-J	12.4	EMPC-J	0.804	J	0.762	J	0.554	EMPC-J	0.734	EMPC-J
E1668A	PCB-127	ng/l	0.774	EMPC-J	0.886	EMPC-J	0.75	J	<0.347	U	0.508	J	0.378	EMPC-J
E1668A	PCB-128	ng/l	67		66.7		52.4		44.6		44.7		40.9	
E1668A	PCB-129	ng/l	492		476		389		334		325		300	
E1668A	PCB-13	ng/l		C12		C12		C12		C12		C12		C12
E1668A	PCB-130	ng/l	27.1		28.3		22.4		19.2		18.7		17.4	
E1668A	PCB-131	ng/l	6.27		6.76		5.46		3.99	EMPC-J	4.99		4.43	
E1668A	PCB-132	ng/l	142		158		119		101		102		92.3	
E1668A	PCB-133	ng/l	5.77		6.41		5.23		4.04		3.95	EMPC-J	3.78	J
E1668A	PCB-134	ng/l	23.5		25		20.8		17.5		17.8		16.6	
E1668A	PCB-135	ng/l	144		116		121		149		87.1		78.8	
E1668A	PCB-136	ng/l	61		46.4		43.9		53.2		32.7		30.7	
E1668A	PCB-137	ng/l	21.9		22.8		19.6		16.8		15.9		14.9	
E1668A	PCB-138	ng/l		C129		C129		C129		C129		C129		C129
E1668A	PCB-139	ng/l	8.19		8.4		6.91		5.65		6.31		5.76	
E1668A	PCB-14	ng/l	0.0257	EMPC-J	<0.0664	U	<0.148	U	<0.310	U	0.16	EMPC-J	0.183	EMPC-J
E1668A	PCB-140	ng/l		C139		C139		C139		C139		C139		C139
E1668A	PCB-141	ng/l	85.5		92.1		73.2		62.9		62		55.6	
E1668A	PCB-142	ng/l	<0.313	U	<0.326	U	<0.309	U	<0.506	U	<0.270	U	<0.324	U
E1668A	PCB-143	ng/l		C134		C134		C134		C134		C134		C134
E1668A	PCB-144	ng/l	30.3		25.1		18.4		19.2	EMPC-J	12.5		11.9	
E1668A	PCB-145	ng/l	<0.208	U	<0.179	U	<0.233	U	<0.475	U	<0.162	U	<0.184	U
E1668A	PCB-146	ng/l	61		65.1		51		43.5		43.1		39.5	
E1668A	PCB-147	ng/l	335		353		285		230		236		217	

E1668A	PCB-148	ng/l	<0.291	U	<0.251	U	<0.326	U	<0.664	U	<0.227	U	<0.257	U
E1668A	PCB-149	ng/l		C147		C147		C147		C147		C147		C147
E1668A	PCB-15	ng/l	41		49.4		45.5		45.2		42.3		41	
E1668A	PCB-150	ng/l	<0.203	U	<0.175	U	<0.228	U	<0.463	U	<0.158	U	<0.179	U
E1668A	PCB-151	ng/l		C135		C135		C135		C135		C135		C135
E1668A	PCB-152	ng/l	0.356	J	0.329	EMPC-J	<0.232	U	<0.472	U	<0.161	U	<0.183	U
E1668A	PCB-153	ng/l	386		402		319		268		267		249	
E1668A	PCB-154	ng/l	3.55	J	2.07	EMPC-J	2.75	EMPC-J	2.91	EMPC-J	2.09	J	2.86	J
E1668A	PCB-155	ng/l	0.834	EMPC-J	0.846		0.504	J	<0.450	U	<0.154	U	<0.174	U
E1668A	PCB-156	ng/l	57		50.1		42.2		42.7		35.8		34.2	
E1668A	PCB-157	ng/l		C156		C156		C156		C156		C156		C156
E1668A	PCB-158	ng/l	51.2		47.6		40		33.3		32.3		29.6	
E1668A	PCB-159	ng/l	4.14		4.42		2.81	J	2.34	EMPC-J	2.59	J	2.43	J
E1668A	PCB-16	ng/l	137	J	188	J	136	J	88	J	158		153	
E1668A	PCB-160	ng/l		C129		C129		C129		C129		C129		C129
E1668A	PCB-161	ng/l	<0.207	U	<0.216	U	<0.204	U	<0.335	U	<0.179	U	<0.215	U
E1668A	PCB-162	ng/l	2.03	EMPC-J	2.19	EMPC-J	1.76	EMPC-J	1.79	EMPC-J	1.57	EMPC-J	1.3	EMPC-J
E1668A	PCB-163	ng/l		C129		C129		C129		C129		C129		C129
E1668A	PCB-164	ng/l	28		29		23.5		20.4		19.5		18.1	
E1668A	PCB-165	ng/l	<0.228	U	<0.237	U	<0.225	U	<0.368	U	<0.197	U	<0.236	U
E1668A	PCB-166	ng/l		C128		C128		C128		C128		C128		C128
E1668A	PCB-167	ng/l	14.8		13		12.7		13.4		11.9		10.7	
E1668A	PCB-168	ng/l		C153		C153		C153		C153		C153		C153
E1668A	PCB-169	ng/l	10.3	EMPC-J	9.47	EMPC-J	1.29	EMPC-J	0.354	EMPC-J	0.54	EMPC-J	0.803	EMPC-J
E1668A	PCB-17	ng/l	166	J	226	J	170	J	110	J	193		184	
E1668A	PCB-170	ng/l	109		95.4		68.8		68.1		63		57.9	
E1668A	PCB-171	ng/l	31.8		26.5		23.1		25.6		19.1		18	
E1668A	PCB-172	ng/l	18.2		16.1		14.4		14.3		11.5		11.3	
E1668A	PCB-173	ng/l		C171		C171		C171		C171		C171		C171
E1668A	PCB-174	ng/l	105		99.1		82.2		85.4		65.6		61.8	
E1668A	PCB-175	ng/l	3.82		3.78		3.51	J	3.13	J	2.6	EMPC-J	2.57	J
E1668A	PCB-176	ng/l	13.4		12.6		10.8		10.3		8.48		8.53	
E1668A	PCB-177	ng/l	60.3		51.2		44.6		46.2		35.9		34.2	
E1668A	PCB-178	ng/l	22.4		19.8		17.7		16.9		14		13.1	
E1668A	PCB-179	ng/l	43.6		45.5		37.3		38.3		30.4		28.7	
E1668A	PCB-18	ng/l	378	J	531	J	368	J	239	J	420		407	
E1668A	PCB-180	ng/l	260		203		188		201		152		145	
E1668A	PCB-181	ng/l	0.774		0.642		0.62	J	<0.360	U	0.883	J	<0.213	U
E1668A	PCB-182	ng/l	0.473		<0.219	U	<0.209	U	<0.350	U	<0.182	U	<0.207	U
E1668A	PCB-183	ng/l	80.9		76.7		63.3		66.3		51.3		47.7	
E1668A	PCB-184	ng/l	<0.161	U	<0.186	U	<0.177	U	<0.297	U	<0.154	U	<0.176	U
E1668A	PCB-185	ng/l		C183		C183		C183		C183		C183		C183
E1668A	PCB-186	ng/l	<0.156	U	<0.181	U	<0.172	U	<0.289	U	<0.150	U	<0.170	U
E1668A	PCB-187	ng/l	142		129		109		110		85		82.1	
E1668A	PCB-188	ng/l	<0.139	U	<0.142	U	<0.148	U	<0.276	U	<0.132	U	<0.159	U
E1668A	PCB-189	ng/l	3.21		3.07		2.64	J	1.96	J	2.36	J	2.14	J
E1668A	PCB-19	ng/l	29.8	J	41.2	J	27.6	J	18.5	J	34		31.8	
E1668A	PCB-190	ng/l	19.1		14.6		13.8		16.1		12.1		11.9	
E1668A	PCB-191	ng/l	4.34		3.46		3.3	J	3.35	J	2.95	J	2.73	EMPC-J
E1668A	PCB-192	ng/l	<0.166	U	<0.192	U	<0.183	U	<0.307	U	<0.159	U	<0.181	U
E1668A	PCB-193	ng/l		C180		C180		C180		C180		C180		C180
E1668A	PCB-194	ng/l	69.2		54.5		49		42		40.9		39.5	
E1668A	PCB-195	ng/l	22.4		21		17.7		14.5		15		14	

E1668A	PCB-196	ng/l	31.7		25.1		24.2	J	33.4	J	19		18.5	
E1668A	PCB-197	ng/l	2.29		1.84		1.92	J	1.9	J	1.59	J	1.35	J
E1668A	PCB-198	ng/l	79.3		60.4		56.9		76.3		45.5		44.4	
E1668A	PCB-199	ng/l		C198		C198		C198		C198		C198		C198
E1668A	PCB-2	ng/l	0.458		0.502		<0.0338	U	<0.0551	U	0.379	EMPC-J	0.44	J
E1668A	PCB-20	ng/l	771	J	702		732		543		595		550	
E1668A	PCB-200	ng/l	7.61		6.82		6.32		7.12		4.6		4.71	
E1668A	PCB-201	ng/l	8.11		7.51		7.11		7.54	EMPC-J	5.31		5.16	
E1668A	PCB-202	ng/l	14.8		13.6		12.6		13.6	EMPC-J	9.1		9.25	
E1668A	PCB-203	ng/l	42.9		36.9		34.1	J	46.7	J	27.4		26.7	
E1668A	PCB-204	ng/l	<0.124	U	<0.156	U	<0.213	U	<0.330	U	<0.148	U	<0.176	U
E1668A	PCB-205	ng/l	3.42		3.2		2.5	J	1.82	J	1.98	J	2.22	J
E1668A	PCB-206	ng/l	32.5		28.5		24.6		18.8		21.2	EMPC-J	19.1	
E1668A	PCB-207	ng/l	2.75		2.88		2.96	J	1.89	J	2.15	J	2.1	J
E1668A	PCB-208	ng/l	9.25		9.49		8.8		7.67		6		5.9	
E1668A	PCB-21	ng/l	362		344		360	J	260	J	301		277	
E1668A	PCB-22	ng/l	232		215		221	J	157	J	183		168	
E1668A	PCB-23	ng/l	<0.0981	U	0.753	EMPC-J	0.683	J	0.505	J	0.562	EMPC-J	0.608	J
E1668A	PCB-24	ng/l	3.54	J	5.8	J	4.62		3.57	J	4.99		6.04	
E1668A	PCB-25	ng/l	50.1		45.5		45.7	J	32.4	J	36.4		34	
E1668A	PCB-26	ng/l	117		106		107	J	76.3	J	89.8		81.9	
E1668A	PCB-27	ng/l	20.8		28		20.9		13.7		23.3		22.8	
E1668A	PCB-28	ng/l		C20		C20		C20		C20		C20		C20
E1668A	PCB-29	ng/l		C26		C26		C26		C26		C26		C26
E1668A	PCB-3	ng/l	1.26		1.33		0.167	EMPC-J	0.265	J	1.27	J	1.28	J
E1668A	PCB-30	ng/l		C18		C18		C18		C18		C18		C18
E1668A	PCB-31	ng/l	696	J	642	J	668		496		554		512	
E1668A	PCB-32	ng/l	84.4	J	129	J	109	J	68.9	J	122		119	
E1668A	PCB-33	ng/l		C21		C21		C21		C21		C21		C21
E1668A	PCB-34	ng/l	5.15		3.99		4.16		2.87	J	3.14	J	2.89	J
E1668A	PCB-35	ng/l	8.7		8.34		7.16		5.05		6.34		5.51	
E1668A	PCB-36	ng/l	0.489		<0.0826	U	<0.125	U	<0.228	U	<0.117	U	<0.116	U
E1668A	PCB-37	ng/l	125		122		122	J	85.4	J	105		92.1	
E1668A	PCB-38	ng/l	0.427	EMPC-J	0.502	EMPC-J	0.665	J	0.409	EMPC-J	0.637	EMPC-J	0.378	EMPC-J
E1668A	PCB-39	ng/l	4.76		4.32		4.44		3.09	J	3.77	J	3.38	J
E1668A	PCB-4	ng/l	60.5		54.8		63		60.1		59.8		59.1	
E1668A	PCB-40	ng/l	395		434		347		322		279		263	
E1668A	PCB-41	ng/l		C40		C40		C40		C40		C40		C40
E1668A	PCB-42	ng/l	188		210		170		154		135		127	
E1668A	PCB-43	ng/l	26.7		30.3		25.1		25.9		20.3		20.1	
E1668A	PCB-44	ng/l	709		786		631		593		501		475	
E1668A	PCB-45	ng/l	132		149		123		114		96.7		92	
E1668A	PCB-46	ng/l	46.1		51.5		39		36.6		31.9		30.1	
E1668A	PCB-47	ng/l		C44		C44		C44		C44		C44		C44
E1668A	PCB-48	ng/l	199		217		167		154		131		127	
E1668A	PCB-49	ng/l	481		528		413		391		325		310	
E1668A	PCB-5	ng/l	0.955		1.25	EMPC-J	1.33	J	1.33	EMPC-J	1.31	EMPC-J	1.18	EMPC-J
E1668A	PCB-50	ng/l	108		114		88.9		81.7		67.6		65.8	
E1668A	PCB-51	ng/l		C45		C45		C45		C45		C45		C45
E1668A	PCB-52	ng/l	840	J	930	J	741		706		586		561	
E1668A	PCB-53	ng/l		C50		C50		C50		C50		C50		C50
E1668A	PCB-54	ng/l	1.01		1.04		1.02	EMPC-J	<1.49	U	0.881	J	0.681	EMPC-J
E1668A	PCB-55	ng/l	9.35	EMPC-J	10.3		13.3		9.62	EMPC-J	9.88		11.4	

E1668A	PCB-56	ng/l	298		314		258		241		214		199	
E1668A	PCB-57	ng/l	2.67	EMPC-J	3.43		3.1	J	2.12	EMPC-J	2.3	J	2.33	J
E1668A	PCB-58	ng/l	2.1		1.47	EMPC-J	1.7	J	1.04	EMPC-J	0.746	EMPC-J	0.631	EMPC-J
E1668A	PCB-59	ng/l	61.7		68.3		55.4		53.1		43.5		42.4	
E1668A	PCB-6	ng/l	24.2		25.4		25.4		26.2		24.8		23.3	
E1668A	PCB-60	ng/l	114		127		115		105		95.7		87.8	
E1668A	PCB-61	ng/l	1040		1210		1070		1060		874		831	
E1668A	PCB-62	ng/l		C59		C59		C59		C59		C59		C59
E1668A	PCB-63	ng/l	25		28.9		24.1		23		19.7		18.3	
E1668A	PCB-64	ng/l	311		340		272		256		221		207	
E1668A	PCB-65	ng/l		C44		C44		C44		C44		C44		C44
E1668A	PCB-66	ng/l	623	J	671	J	581		558		465		442	
E1668A	PCB-67	ng/l	18.2		22.2		18.7		17.7		15.1		14.8	
E1668A	PCB-68	ng/l	2.1	EMPC-J	2.64		2.18	J	1.63	EMPC-J	1.73	J	1.75	J
E1668A	PCB-69	ng/l		C49		C49		C49		C49		C49		C49
E1668A	PCB-7	ng/l	4.41		4.75		4.42		4.58	EMPC-J	4.24	EMPC-J	4.13	EMPC-J
E1668A	PCB-70	ng/l		C61		C61		C61		C61		C61		C61
E1668A	PCB-71	ng/l		C40		C40		C40		C40		C40		C40
E1668A	PCB-72	ng/l	4.57		4.76		3.72	J	3.43	J	3.16	J	3.29	J
E1668A	PCB-73	ng/l		C43		C43		C43		C43		C43		C43
E1668A	PCB-74	ng/l		C61		C61		C61		C61		C61		C61
E1668A	PCB-75	ng/l		C59		C59		C59		C59		C59		C59
E1668A	PCB-76	ng/l		C61		C61		C61		C61		C61		C61
E1668A	PCB-77	ng/l	32.6		35.2		34.4		36.6		29.5		27	
E1668A	PCB-78	ng/l	0.392	EMPC-J	<0.176	U	<0.145	U	<0.390	U	<0.149	U	<0.196	U
E1668A	PCB-79	ng/l	6.92		5.78	EMPC-J	4.59		4.23		3.87	J	4.03	
E1668A	PCB-8	ng/l	124		135		135		145		122		120	
E1668A	PCB-80	ng/l	<0.135	U	<0.151	U	<0.124	U	<0.334	U	<0.128	U	<0.168	U
E1668A	PCB-81	ng/l	1.47		1.15	EMPC-J	1.26	J	1.37	J	1.45	J	1.29	J
E1668A	PCB-82	ng/l	62.8		54		58.5		73.1		50.8		44.6	
E1668A	PCB-83	ng/l	320		282		278		329		242		217	
E1668A	PCB-84	ng/l	143		131		118		137		104		93.3	
E1668A	PCB-85	ng/l	103		83.5		84.8		103		74.7		65.1	
E1668A	PCB-86	ng/l	325		295		298		354		265		232	
E1668A	PCB-87	ng/l		C86		C86		C86		C86		C86		C86
E1668A	PCB-88	ng/l	68.2		68.7		67.6		79.3		58.5		52.3	
E1668A	PCB-89	ng/l	10.1		9.26		8.92		8.55	EMPC-J	7.62		7.43	
E1668A	PCB-9	ng/l	6.81		7.49		7.71		7.56		7.43		7.06	
E1668A	PCB-90	ng/l	502		472		461		551		408		359	
E1668A	PCB-91	ng/l		C88		C88		C88		C88		C88		C88
E1668A	PCB-92	ng/l	81.6		78.2		73.3		90.4		67.3		58.4	
E1668A	PCB-93	ng/l	2.86	EMPC-J	2.63	EMPC-J	2.83	EMPC-J	2.49	EMPC-J	1.12	EMPC-J	2.38	EMPC-J
E1668A	PCB-94	ng/l	2.64	EMPC-J	2.91		2.34	J	1.92	EMPC-J	2.16	J	2.21	J
E1668A	PCB-95	ng/l	411	J	396	J	347		404		302		272	
E1668A	PCB-96	ng/l	5.32		5.32		4.77		5.04		4.16		3.71	J
E1668A	PCB-97	ng/l		C86		C86		C86		C86		C86		C86
E1668A	PCB-98	ng/l	19.9		19.3		17.2		21.2		15.5		13.7	
E1668A	PCB-99	ng/l		C83		C83		C83		C83		C83		C83
E1668A	Decachlorobiphenyl	ng/l	18.9		<0.172	U	16		14.7		13.3		11.4	
E1668A	Dichlorobiphenyl	ng/l	305	EMPC-J	326	EMPC-J	341		346	EMPC-J	314	EMPC-J	307	EMPC-J
E1668A	Heptachlorobiphenyl	ng/l	918		800		683		707		557	EMPC-J	528	EMPC-J
E1668A	Hexachlorobiphenyl	ng/l	2070	EMPC-J	2060	EMPC-J	1680	EMPC-J	1490	EMPC-J	1380	EMPC-J	1280	EMPC-J
E1668A	Monochlorobiphenyl	ng/l	4.83		5.1		2.4	EMPC-J	1.94	EMPC-J	5.07	EMPC-J	5.11	J

E1668A	Nonachlorobiphenyl	ng/l	44.5		40.9		36.3		28.4		29.3	EMPC-J	27.1	
E1668A	Octachlorobiphenyl	ng/l	282		231		212	J	245	EMPC-J	170		166	
E1668A	Pentachlorobiphenyl	ng/l	3370	EMPC-J	3170	EMPC-J	3030	EMPC-J	3420	EMPC-J	2560	EMPC-J	2310	EMPC-J
E1668A	Tetrachlorobiphenyl	ng/l	5680	EMPC-J	6290	EMPC-J	5210	EMPC-J	4950	EMPC-J	4170	EMPC-J	3970	EMPC-J
E1668A	Trichlorobiphenyl	ng/l	3190	EMPC-J	3340	EMPC-J	3110	J	2200	EMPC-J	2830	EMPC-J	2650	EMPC-J
SW1613B	1,2,3,4,6,7,8-HpCDD	pg/L	1040	J	2810	J	869		833		967		901	
SW1613B	1,2,3,4,6,7,8-HpCDF	pg/L	1260	J	1120	J	987	J	934	J	1010	J	999	J
SW1613B	1,2,3,4,7,8,9-HpCDF	pg/L	54.4		54.2		40.1		38.9		44.1		41.7	
SW1613B	1,2,3,4,7,8-HxCDD	pg/L	13.7	J	25.8		12.8	J	9.73	EMPC-J	15.2	J	14.3	J
SW1613B	1,2,3,4,7,8-HxCDF	pg/L	308		291		253		240		259		260	
SW1613B	1,2,3,6,7,8-HxCDD	pg/L	79.9		107		67.8		65.2		71.1		68.1	
SW1613B	1,2,3,6,7,8-HxCDF	pg/L	81.6		72.5		61.5		58.2		65.1		63.5	
SW1613B	1,2,3,7,8,9-HxCDD	pg/L	32.8		47.9		25.8		24	J	27.8		29.1	
SW1613B	1,2,3,7,8,9-HxCDF	pg/L	<3.13	U	<4.04	U	<2.5	U	<2.38	U	<3.8	U	<3.28	U
SW1613B	1,2,3,7,8-PeCDD	pg/L	21.4	J	24.5	J	18.2	J	18.3	J	21	J	18.2	J
SW1613B	1,2,3,7,8-PeCDF	pg/L	26		26.3		20.2	J	20.3	J	22.1	J	23.8	J
SW1613B	2,3,4,6,7,8-HxCDF	pg/L	51		50.8		44.7		41.1		47.3		47	
SW1613B	2,3,4,7,8-PeCDF	pg/L	89.5		94.3		78.5		75.8		82.9		80.6	
SW1613B	2,3,7,8-TCDD	pg/L	5150		4920		4430		4200		4380		4370	
SW1613B	2,3,7,8-TCDF	pg/L	64.4		58.3		50.8		46.9		71.9		58.2	
SW1613B	OCDD	pg/L	10300	J	24800	J	8310		8460		9640		9110	
SW1613B	OCDF	pg/L	2270		2070		1820		1710		1960		1830	
SW1613B	Total Hepta-Dioxins	pg/L	2100	J	6790	J	1730		1660		1960		1820	
SW1613B	Total Hepta-Furans	pg/L	2030	J	1850	J	1620	J	1540	J	1690	J	1660	J
SW1613B	Total Hexa-Dioxins	pg/L	510	EMPC-J	977	J	446		427	EMPC-J	492		467	
SW1613B	Total Hexa-Furans	pg/L	1510	EMPC-J	1400	EMPC-J	1240		1180	EMPC-J	1330		1280	EMPC-J
SW1613B	Total Penta-Dioxins	pg/L	200	EMPC-J	241	EMPC-J	185	EMPC-J	175	EMPC-J	193	EMPC-J	189	EMPC-J
SW1613B	Total Penta-Furans	pg/L	3070		2750	EMPC-J	2660		2610		2910		2900	EMPC-J
SW1613B	Total Tetra-Dioxins	pg/L	5820	EMPC-J	5600	EMPC-J	5030	EMPC-J	4780		4960		4940	EMPC-J
SW1613B	Total Tetra-Furans	pg/L	5800		5810	EMPC-J	4970	EMPC-J	4980		5110	EMPC-J	5160	EMPC-J
SW9060	Dissolved Organic Carbon	mg/l	81.1		84.4		87.1				129			
SW9060	Total Organic Carbon	mg/l	84.7		74.5		81.9				106		106	

Using Averaged Pore Water Chemistry and Groundwater Flux Data to Design the RM 10.9 Cap's Active Layer

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This memorandum outlines the rationale for using the averaged values of groundwater flux and pore water chemistry in design of the RM 10.9 cap's active layer. The memorandum explains how the use of the averaged data provides a reasonably conservative set of input parameters to the CapSim model, which was used to design the cap's active layer and results in the cap's active layer being protective of both human health and the environment.

An engineered cap with an active layer will be placed at the RM 10.9 after dredging the top two feet of sediment. The design of the cap's active layer utilized two sets of site-specific data – groundwater flux and pore water chemistry – that are inputs to the CapSim model. The groundwater flux input parameter was based on the average of each of the four measuring stations where groundwater seepage was measured in April 2013. The pore water chemistry data were obtained in February 2013 by averaging the results of pore water composite samples generated from sediment cores collected from locations with the 10 highest sediment concentrations of PCDDs/PCDFs, PCBs, and mercury[1] within the 2 to 4 ft depth interval. Thus, the pore water chemistry data are biased high and since the pore water concentrations are proportional to sediment concentrations, many areas within the Removal Area will have concentrations in pore water that are orders of magnitude lower than those used in the CapSim modeling. The COPC concentration sediment found in sediment below the 2 ft dredge depth are shown.

RM 10.9 Removal Area Summary of Chemical Parameters in Sediment

		Depth Interval					
		2.5 to 3.5 ft bgs			3.5 to 5.5 ft bgs		
Analyte	**Conc.**	**Max.**	**Min.**	**Avg.**	**Max.**	**Min.**	**Avg.**
2,3,7,8-TCDD	ng/kg	29,800	1.0	9,478	18,750	0.35	3,493
Total PCBs	mg/kg	28	0.00012	10	25	0.000013	4.5
Mercury	mg/kg	19	0.0078	7.6	17	0.0043	6.0

Average vs. Maximum Values

As noted in Calculating *Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10 December 2002), "EPA recommends using the average concentration to represent "a

[1] Sediment data collected during the 2011 and 2012 characterizations of the RM 10.9 were used to identify pore water sampling locations.

reasonable estimate of the concentration likely to be contacted over time" (EPA 1989)." The referenced EPA 1989 guidance (*Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A). Interim Final.* EPA/540/1-89/002) states "The concentration term in the intake equation is the arithmetic average of the concentration that is contacted over the exposure period. Although this concentration does not reflect the maximum concentration that could be contacted at any one time, it is regarded as a reasonable estimate of the concentration likely to be contacted over time. This is because in most situations, assuming long-term contact with the maximum concentration is not reasonable." This and other similar guidance has resulted in site-specific, surface-weighted average concentrations (SWAC) being utilized as design criteria on a number of sediment remediation projects (e.g., Lower Fox River, Kalamazoo River, Buffalo River, River Raisin, Waukegan Harbor). The SWAC represents the average contaminant concentration in the biologically active portion of sediment.

Reasonably Conservative Design Parameters

The purpose of the cap's active layer is to reduce the contaminant flux from the underlying sediment into both the bioavailable zone and surface water above the cap's active layer; controlling the flux also results in controlling the contaminant concentration in each. The active layer's design criterion is to control the average contaminant concentrations in the bioavailable zone and surface water, which is similar to achieving a SWAC as a sediment remedial criterion. Thus, it is appropriate to use the average, not the maximum, groundwater flux and pore water chemistry data for design of the active layer. However, as previously discussed, the chemistry data were biased high. Therefore, the overall effect of utilizing the average groundwater flux and the average (although biased high) pore water chemistry provides a reasonably conservative set of input parameters for the design of the cap's active layer and predicting its long-term effectiveness.